SOME DESIRABLE CURRICULUM ADJUST-
MENTS IN SCIENCE AND MATHEMATICS

A Paper Panel

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In its studies during the past two years, the Curriculum Com-
mittee of The Central Association of Science and Mathematics
Teachers has become conscious of a number of questions con-
cerning curriculum adjustment, questions the answers to which
every earnest teacher would like to find. Perhaps there is no
final answer to these questions, but progress toward satisfactory
answers is being made here and there. We decided to seek out
some of those who are in a position to suggest answers to a few
of these questions and to ask them to make their experience
available for our members. In this "paper panel discussion" we
present the questions which we selected and the answers given
by those to whom they were addressed.

Those participating in the panel are:

Miss Veva McAtee, Teacher of Science, Hammond, Ind.

Mr. Ira C. Davis, Teacher of Science, University High School,
Madison, Wis.

Mr. Joseph A. Nyberg, Teacher of Mathematics, Hyde Park
High School, Chicago.

*Mr. Davis, should mathematics teachers provide remedial classes
to help pupils learn the mathematics they need to use in science
classes?*

Mr. Davis' Answer

Evidence seems to indicate that any special applications of mathematics in science must be taught through specific drills. Pupils may have learned to perform some operations in mathematics without reorganizing the same operations in some science class. Science teachers cannot expect pupils to come to their classes and be prepared to solve all of the mathematical problems which occur. They must teach the special or specific applications of mathematics themselves. Pupils have as much difficulty with language and vocabulary as they do with mathematics, but difficulties in both areas are relative, that is, some pupils have many more serious difficulties than others. Certainly no one problem will provide serious difficulties for everyone in class. It naturally follows that science teachers should not expect their pupils to be so well prepared they will have no difficulties.

The question to be answered then is this—Are the methods of teaching being used giving pupils a thorough enough training in mathematics to prepare them to enter classes in physics and chemistry? The decreased emphasis on mathematics the past few years cannot possibly increase the quality of this training. Competence in mathematics cannot be acquired by a year's course in mathematics. Real competence is not apparent until pupils have completed at least three years of high school mathematics. Competence in mathematics means more than being able to make calculations. It means the ability to think mathematically. I do not intend to say pupils should have three years of mathematics before they enter physics or chemistry classes, but rather to emphasize the point that competence in mathematics is not easily acquired. Science teachers should not expect it of pupils whose preparation has been inadequate.

Science tends to become more quantitative. That means much of it is being reduced to measurable terms. If quantities are measured they will be expressed in mathematical quantities. Quantities in science mean more than simple mathematical concepts. The unit of power includes the units of distance expressed in feet, force expressed in pounds and time expressed in seconds. It would be easy enough to visualize the units of weight, distance and time separately, because they are measurable and observable, but you cannot observe or visualize power by itself. Power does not exist by itself apart from other things. It exists as a relationship or ratio between three factors, none of which

need remain constant. Many other units such as foot-pound, density, kilowatt hour, foot candle and decibel can best be taught in science classes. However cooperation between science and mathematics teachers will make it possible to discover the areas in which each can make the greatest contributions. The mathematics teachers need to prepare pupils for the other divisions of subject matter as well as for science. What are the common fundamentals of mathematics which may be used in all of these areas? If these common fundamentals are well taught, the mathematics teachers have done their part.

If my interpretation of the question is correct, it is assumed remedial teaching is necessary. The mathematics teachers want to know if special classes taught by mathematics teachers will remedy the situation. The answer is yes if the teachers of mathematics will attempt to learn the science for which the mathematics is to be used and the science teachers will determine what mathematics their pupils need to learn for each specific type of problem which is to be taught. This means that science teachers must determine the learning difficulties in each problem. These difficulties will not be common to any one subject matter area, but will cut across several areas. For this reason neither the science or mathematics teachers will be able to visualize in advance all of the difficulties. Some research the writer has carried on indicates that many problems contain as many as forty or fifty specific and different learning difficulties. Often times they occur where least expected.

If these remedial teaching classes are to be worth while they must be based on learning difficulties. At present our knowledge of these difficulties is so meager, we are not justified in saying we know how to proceed. Assuming that teachers do respectably well in teaching problems involving the use of inverse squares, how can we explain the fact that in some cases 90 to 95 per cent of the pupils will fail to solve these problems on examination? The understanding of the law of inverse squares is necessary if pupils are to solve problems on sound, light, and heat intensity, on lighting and heating our homes, on calculating resistances of wires, the rate of vibration of wires, radio broadcasting, television, construction of microscopes and telescopes and many others. What teacher has learned how to present the law of inverse squares to pupils so they will have a clear understanding of it?

I am optimistic enough to believe that most of our pupils will

be able to solve the mathematical problems in physics and chemistry if we will take the time and patience to find out what makes these problems difficult. This means real research studies for many teachers. If the problems we call difficult can be broken down into each specific learning difficulty involved, we will discover why pupils have difficulty. Furthermore, when specific learning difficulties are discovered, we will be able to plan our teaching procedures so more time and emphasis will be given where needed.

I believe this problem in chemistry will help to make clear what I mean by learning difficulties. "How much sodium hydroxide is needed to neutralize 50 grams of hydrochloric acid?" How many learning difficulties does this problem involve? How many of them are mathematical? How many chemical? How many vocabulary? Then let us assume that the pupils are requested to neutralize the 50 grams of the acid with the sodium hydroxide in the laboratory. What further difficulties would be involved? In the first place the acid might not be pure. How much impure acid would pupils need to use to get the 50 grams of the pure acid? This problem also involves the understanding of ratio and proportion. Teachers have found as many as ninety learning difficulties in this problem in chemistry. No wonder our pupils have difficulties in solving problems.

As a final answer then let us first of all find out what learning difficulties our pupils have. When this has been done we will be ready to plan our remedial teaching classes.

Mr. Nyberg, where and how in our high school curriculum can we provide for adequate experience in correct logical thinking on non-geometric subjects?

MR. NYBERG'S ANSWER

In my experience the concepts of reasoning can best be started after the pupil has had some introduction to the methods used in geometry. To learn anything, whether it is French, Algebra, or Woodworking, the pupil must have some material with which he can practice. And the material must be such that there can be no quibbling about the answer to the problem. Geometry furnishes more material of this type than do the social sciences or any other field.

If we make a list of the ideas of elementary logic with which the pupil should become familiar it would read about as follows: The significance of definitions, the unavoidability of having

some undefined terms and assumptions, and the manner in which we use a general statement, a specific statement and a conclusion to form a syllogism. Beginners in geometry are greatly puzzled over the word *prove*, and they wonder how we can prove a statement if we are not allowed to measure nor to judge by appearances. If we are not afraid to use the notions of a syllogism we can explain quite early that a statement is proved when we can build a syllogism of which the statement is the conclusion.

All this work, however, exemplifies only deductive reasoning. And since geometric reasoning is mostly deductive, the pupil may leave the class thinking that all reasoning is deductive. Hence, even though we break the continuity of the work in geometry, the teacher should at some place teach something about inductive reasoning, and should do enough work with it to enable the pupil to see the difference between inductive and deductive reasoning. Further, we should not hesitate to encroach somewhat on the field of elementary science by discussing how inductive and deductive reasoning are the bases for what we now call the scientific method of problem solving.

Even if we do all this, we have still not done our full duty to the pupil unless we devote some time to discussing some of the typical errors in reasoning. Here I wish to recommend a reading of *How To Think Straight*, by R. H. Thouless (Simon and Shuster, $2.00). This is a revised and American edition of his book called *Straight and Crooked Thinking*. Such topics as ad hominem reasoning, reasoning in a circle, faulty analogies, poor authorities, non-causal relations, assuming a converse, avoiding the question, appeals to prejudice, and the technique of propaganda may have little to do with geometry, and the material is not found in mathematical fields, but they are highly important. We cannot expect the English or Latin or Chemistry teacher to include them in their courses; the Geometry teacher must do this work.

It is obvious that the present course in geometry cannot include this new material without discarding some of the old material. To answer the HOW of this question would take considerable time but I expect soon to report in SCHOOL SCIENCE AND MATHEMATICS the nature of my own attempts to provide time for the new work. There is no doubt that the time must be found somewhere, and whatever is educationally desirable should be administratively possible. The start must be made in

the geometry class, and the mathematics teacher is best fitted
to continue the work.

*Miss McAtee, how can very young pupils be given experiences
that will help them learn the scientific method?*

MISS MCATEE'S ANSWER

The scientific method is the correct way to reason out prob-
lematic situations. Children in the very early grades will learn
to do this by following through with the teacher and will even-
tually be led to form the correct habits of reasoning by the imi-
tating of good examples set before them by the teacher herself.
Therefore, it is imperative that the teacher be faultless in pre-
senting only the proper methods of reasoning or thought pro-
cedures. This can be done through simple experiments in the
very lower grades, but the danger from experiments here lies in
the fact that many teachers do not know the true meaning of
experiment. An experiment is a question put to the test. If there
is no question, there is no experiment. The scientific method is
the most reasonable procedure to use in finding the answer to a
question.

Very young pupils have no difficulty in finding problems. The
teacher is constantly confronted with "What is it?", "Why is
it?", "How does it work?" Children learn by asking questions,
but we must not close the channel of thought which they have
opened when a question confronts them by immediately sup-
plying the answer. Progress has been made only because man
had that spirit of inquiry which led him on—perhaps at first
only to satisfy a curiosity which later developed into a real in-
terest. So it is with the child. He may ask, "What makes the
wind blow?" and before you have had a chance to recognize his
question, he has asked, "Why does the dog have his tongue
hanging out?" It would be hard to determine which of the child's
first questions were ones of real interest or only momentary
curiosity.

However, the most essential factor of the scientific attitude is
the inquiring mind. We must cultivate it—not curb it. We must
keep the students alert to what is going on about them, to ask
questions, wish to try things out for themselves, not to be easily
swayed or indifferent. An activity program in elementary
science is one way to develop interests through meeting situa-
tions and experience which will contribute to the use of the
scientific method. In such a program, the teacher must have a

wide range of interests and experiences in both the biological and physical environment, she must study each new situation as it arises and plan methods which may be used to help the student obtain the needed information for himself. Children must be given experiences. "Learn through doing" is just another phase of the scientific method. Reading is another way of establishing contacts with objects and natural forces through the experiences of others.

My final answer to the question would be, therefore, that very young pupils can be given experiences that will help them learn the scientific method through:

1. An activity program in elementary science providing personal, first-hand acquaintance with the objects and forces of the child's natural environment.
2. An opportunify for the child to observe good examples of the scientific method in the classroom under the direction of the teacher.
3. Letting the child learn through doing—take an active part in simple experiments.
4. Develop a reading program which will stimulate the child's interests and provide a rich background of information supplied through the experiences and observations of others.

Mr. Nyberg, do you think it good practice to have a set of problems in a text worked more than once by pupils?

MR. NYBERG'S ANSWER

For some kinds of work the old problems are better than new ones. Almost every day, meaning four days out of five, I begin the recitation in algebra with three to five minutes of review work. This is a sort of limbering up process such as a football coach might use at the beginning of the day's drill, or the preliminary swings that a golfer takes when he walks up to the tee. It is oral work and I use exclusively old exercises, like:

Solve equations like $3y = 13$, $8r = 2$, $5w = 0$

Or, remove parentheses from the equations on a page which the class worked last week. Or, clear of fractions the equations on page 109. The problems are not finished; we do merely what can be done orally. Or, state what multipliers would be used to solve a set of equations by the multiplication-addition method. Find products of binomials. Reduce the radicand in numbers like $\sqrt{120}$.

The great value of using exercises which the pupil worked in the preceding week or month is that the pupil feels that he ought to be able to do this work. He would not have the same attitude toward similar but new problems. Even in written homework I also use old sets of exercises. This is more valuable with a slow group than with a bright group. It helps to develop confidence, which is something that a slow group needs.

There are still other occasions for using old problems. At some stage the class has learned to solve the problem

A man invests part of $3,500 at 6% and the remainder at 5%. How much is invested at each rate if his income from the investment is $205?

Pupils may learn to solve such problems and still miss some of the significant aspects of equations. He should for example learn that x represents dollars and $.06x$ also represents dollars, but x is dollars of investment while $.06x$ is dollars of income. Further, if x represents dollars and if x and y are added, as in the equation $x + y = 3,500$, then y must also represent the same kind of dollars. And if $.06x$ are dollars of income, and if $.06x$ and $.05y$ are added as in the equation $.06x + .05y = 205$, then $.05y$ must also represent dollars of income. That is, each term of the equation must represent the same kind of unit. And his equation is very likely correct because the 205 is also dollars of income, not dollars of investment. (We could, of course, make a problem saying that a man's age plus his telephone number, plus his bank account equalled his car's license number, but that is not a real situation.) When studying equations in this manner it is important to use old problems which the pupil has already solved several times so that he can give his whole attention to the new ideas. I mean we must use not only old types of problems, but the actual problems which have been assigned several times so that even the numbers in the problems will not distract him.

Still later in the year the pupil will generalize this problem into:

A man invests part of P dollars at r% and the remainder at s% so as to get an income of i dollars. Find each investment.

When doing this I take the pupil back to the same problems (not other similar problems but the identical problems) which he studied some months previously so that nothing but the study of generalizing will have his attention.

As one pupil said when he came in for his final examination:

"Give us page 119. There's one page I know. I bet we squeezed the juice out of that page."

Miss McAtee, when should pupils get first experience in using mathematical formulas in their study of science?

Miss McAtee's Answer

My first reaction to this question would be "when the need arises"; and my experience has been that the need does not arise much before the Senior High School. Most of our so-called problems in science before this time are rather problematic situations which have no set formula for solving. There may be several practical ways of arriving at the same conclusion, and the wise teacher will lead the students to find as many of these ways as possible. Below the Senior High School it is the teachers of mathematics who will resort to the field of science for the applications of their mathematical problems. The teachers of science will lead the student to find their answers in the laws and forces of nature rather than man-made laws and formulas. There are some instances, however, where figures might be more startling and make a more lasting impression than a general statement. It is one thing to say that a star is a million light years away, and another to find how long it would take man, traveling at the speed of one of our fastest airplanes, to reach this same star; one thing to say that a certain weed multiplies very rapidly and another to count the seeds on one particular weed and then figure how many plants there would be in the third generation if each seed from the original plant grew and produced in turn as many seeds as the parent plant. It is this type of simple mathematics which should be used below the Senior High School.

I would say that it is only in the more exact and specialized fields of chemistry and physics where there is need of much experience in the use of mathematical formulas.

Mr. Davis, should high schools organize separate courses in physics and chemistry for those who have only the consumer interest in these subjects and have no intention of continuing them with further study?

Mr. Davis' Answer

This question cannot be answered satisfactorily without discussing the present tendencies in curriculum construction. The

new high school will provide a program which will give boys and girls a good general education. Rather than offer new courses, the tendency is to combine or group together the one hundred or more courses now offered in the large modern high school into few areas or cores and require all of the pupils to enroll in these areas. Furthermore the tendency to provide vocational or occupational training is being postponed until boys and girls are nineteen or twenty years of age. Many of our schools seem to be shifting to the 6-4-4 or the 8-3-3 plan. Our educational program is expanding from twelve grades to fourteen grades with emphasis on vocational and technical training in the thirteenth and fourteenth grades. There are two reasons for this shift—first, the decrease in school population in the elementary school and second, the difficulty boys and girls have in getting jobs before they are twenty years of age.

This change in our educational planning makes it necessary for us to evaluate carefully the contributions which our present courses in physics and chemistry can and do make to general education. Boys and girls will find it necessary to live in our future democratic society as well as earn a living. Do our present courses in physics and chemistry contribute enough to these areas to make them worth while? Do they offer as much as other subjects? Would a course in consumer science do more? Admitting that consumer education is a need in general education, does that mean we must offer new courses to acquire it?

Worthwhile consumer education depends on boys and girls being able to make good judgments rather than being able to give a superficial description of some product or series of products. A successful buyer and consumer must assign correct values to these products. Values are judgments, not facts. The value of a product is never written or marked on it. Also the value of any product may change quite rapidly because the values of other products change. Values are always changing. They are never static. They are relative. The ability then to make good judgments depends as much on general information as it does on specific information. Is there any reason why our present courses in physics and chemistry cannot provide the general and specific information which is needed in consumer education? If they do not provide it, is it because their organization is too formal and impractical, or the material taught has no value for consumer education, or the method of teaching used does not contribute to clear thinking? I am not

attempting to defend our present courses in physics and chemistry, but rather to raise the question, what is wrong with them if they do not contribute something which provides a good understanding of consumer education? There is not anything sacred about the subject matter being taught in our present courses. There is no reason why they cannot be changed and revised to meet the new demands in education.

Any good course in consumer education whether new or revised, should provide:

1. A broad base of general information.
2. Complete information on specific objects or materials.
3. A good understanding of social and economic values and trends.
4. Experiences in buying and using goods or materials.
5. A wide range of experiences in thinking in which judgments are based on facts and values.
6. The possibility of using teaching procedures which will develop desirable attitudes.
7. An understanding of the methods buyers and sellers use including high pressure salesmanship.
8. Opportunities for evaluating propaganda and advertising.
9. Some understanding of how goods are produced and distributed. Values and cost of production are closely related to each other.
10. Experiences in balancing budgets or adjusting expenditures to income.

It should be apparent, I believe, that a course in consumer science to be effective must contain some subject matter now taught in social studies, economics and psychology. None of our present high school courses in natural science provide a wide enough range of material in other areas to make them valuable for consumer education. If all of this desirable subject matter is added then the quantity of science taught must be reduced with the result all areas will be treated less thoroughly. I doubt if such a plan will provide a good program for consumer education. Possibly a word of warning is needed at this point. Is it not possible that we may be attempting something which is too difficult for pupils to comprehend at the high school level? Many adults with much more experience than we can expect pupils to have purchase goods largely on an emotional basis. In addition the quantity of money pupils will have is so small

they cannot be expected to acquire much real experience unless we persuade parents that their children be given a much greater share of responsibility in spending the family income. Certainly parents have some responsibility in training their children to be good consumers. The allowances children have to spend should be a personal matter with them and their parents. I question the desirability of teachers prying into children's personal matters too much.

As a final answer to the question proposed, I believe all departments or areas of subject matter have something to contribute to the better understanding of consumer education. Each department should locate the topics or areas which may be emphasized and expanded to give the foundations for partial understandings. Somehow we need to get teachers together to agree on a method which will give pupils an opportunity to correlate what is learned in the different areas. This is as true for conservation and health as it is for consumer education. Such a plan will provide continuous experiences for all pupils throughout their high school careers. If specialized courses are provided, a relatively small percentage of pupils will get experiences for only a semester or year and that is not long enough if we are to expect pupils to get a good understanding of such a complex problem as consumer education.

SEX INSTRUCTION IN SCHOOLS OPPOSED AS UNSCIENTIFIC

Sex instruction in the public schools was opposed on scientific grounds in an address before the meeting of the National Association of Biology Teachers, by Dr. A. C. Kinsey of Indiana University.

"It is the function of a scientist to observe and analyze the material universe, and science is not qualified to evaluate or pass moral judgments on behavior," Dr. Kinsey declared. "The sex instruction which is gradually creeping into our science classrooms is animated by a desire to impose particular systems of morality, and as such, does not belong in our science teaching. The biology of reproduction is a fundamental part of biology and should be presented as scientific data without reference to its social implication.

"Recently published studies are giving us sound scientific data on the nature of human sexual behavior and these should be the source of whatever material science teachers use in the science classroom. If this objective material can not be presented, then considerations of human sexual behavior should be left to someone else than scientists."

THE DETERMINATION OF MOLECULAR DIMENSIONS BY THE OIL FILM METHOD

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Nobody has ever seen a molecule. Light waves are too long for use in measuring the dimensions of such a sub-microscopic particle. Yet the dimensions of these invisible bits of matter may be determined with the simplest apparatus.

Everyone is familiar with the stories of sailors spreading oil on stormy waters in order to quiet the surging waves. It is difficult to believe that oil has the ability to spread over a sufficiently large area to be effective and, at the same time, remain in a continuous and unbroken film. It is this ability of some oils to spread over a water surface which is utilized in the method of obtaining molecular dimensions described below.

When a small quantity of the right kind of oil is allowed to spread freely upon a quiet surface of water the only forces which act to prevent the film from spreading indefinitely are molecular attractions in a horizontal plane. There are no vertical forces which would tend to keep one layer of molecules piled on top of another layer. Hence we assume that such a film is uniformly only one molecule thick. When in equilibrium each molecule is in contact with the water, indicating a tendency to dissolve in the water. It is prevented from dissolving by what appears to be a tendency of one part of the molecule to avoid the water Thus we may say that the tail of an oil molecule attracts water, or is hydrophylic, while the head of the molecule avoids water or is hydrophobic. This gives us a picture of the oil film as consisting of a mono-molecular layer of molecules, each oriented vertically and just barely touching its neighbors. The thickness of the film is thus equivalent to the length of an oil molecule.

The most direct method of measuring the thickness of such a film is to drop a known volume of oil upon a water surface and then measure the area of the film. The volume divided by the area then gives the desired thickness of the film. Since the film is invisible, some means must be devised for determining its boundaries.

In order to do this, the following experimental procedure has been developed.[1]

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[1] Langmuir, *Journal American Chemical Society*, Vol. 39, 1917, pp. 1848–1871.

There is prepared a dilute benzene solution of the oil of accurately determined concentration. The benzene is used because it facilitates the spreading action and obligingly evaporates almost instantly thereafter.

A large photographic tray is used as a container for the water. The tray should be scrupulously cleaned and the water free from dust and dirt particles. Upon the water surface powdered talc (cork dust or lycopodium powder will also serve) is dusted and then blown over the surface to one end of the tray in as straight a line as possible. The talc sweeps away any surface contamination from the area upon which the oil is to be spread. The length of the talc film is now measured with a meter stick. Its width is the same as that of the tray.

Now a few drops of the benzene solution of the oil are allowed to fall upon the free surface of the water. Since most burettes deliver fifty drops to the cc, the volume of the solution applied may be determined by counting the number of drops.

The talc film is then blown back toward the end of the tray containing the oil. When the leading edge of the talc film meets the oil, the talc refuses to be blown any farther. With practice, one can soon learn to blow the talc film so that its outside edge forms a nearly straight line across the tray.

The length of the area of the tray containing the talc and oil films is now measured with a meter stick by observing the distance between the end of the tray and the outer edge of the talc. This measurement gives the sum of the lengths of the oil film and the original talc film. The original length of the talc is subtracted from this sum in order to obtain the average length of the oil film. The width of the oil film is also that of the tray itself.

A complete test run should be made with pure benzene used in place of the solution to determine what fraction of the film area may be due to impurities in the benzene. This correction should be very small.

The simple calculations involved in dividing the volume of the applied oil by its observed area are all that are now necessary to obtain the desired thickness of the film. The volume of the oil applied is determined as the quotient of the concentration of the oil in the solution divided by the density of the oil.

Stearic acid, $C_{17}H_{35}COOH$, and oleic acid, $C_{17}H_{37}COOH$, are convenient substances to use to produce such a mono-molecular film. Following are sample data obtained with stearic acid:

The density of stearic acid is listed as .843. Its concentration

was in the ratio of .00155 grams of acid to one cc of benzene. Since the burette delivered fifty drops per cc, each drop contained .000031 grams of stearic acid. The width of the tray was 39.4 cms. The benzene correction amounted to .2 cm length of film per drop.

Drops Applied	Talc Film Original Length	Talc Oil Film Length	Oil Film		
			Length	Corrected for Benzene	Length Per Drop
4	8.0 cms	23.0 cms	15.0 cms	14.2 cms	3.55 cms
6	6.4 "	28.2 "	21.8 "	20.6 "	3.43 "
8	8.1 "	36.9 "	28.8 "	27.2 "	3.40 "

Average Length: 3.46 cms.

$$\text{Volume} = \text{area} \times \text{thickness} = \frac{\text{concentration}}{\text{density}} \text{ hence;}$$

$$\text{Thickness} = \frac{\text{concentration (grams/drop)}}{\text{length} \cdot \text{width} \cdot \text{density}} = \frac{.000031}{3.46 \times 39.4 \times .84}$$

$$\text{Thickness} = 27 \times 10^{-8} \text{ cms.}$$

This volume for the length of the stearic acid molecule, 27 Ångströms, is reasonably close to the value of 25 Ångströms as given by Langmuir.

The length of the molecule is not all that we can determine from this experiment. The number of molecules in the film can be calculated from the known weight of the oil used, its molecular weight, and Avogadro's number. The division of the film area by the number of molecules present then gives the cross-sectional area of the molecule.

$$n = \frac{.000031}{282} \times 6.06 \times 10^{23} = 6.68 \times 10^{16} \text{ number of molecules in the film}$$

$$A = \frac{39.4 \times 3.46}{6.68 \times 10^{16}} = 20.5 \times 10^{-16} \text{ cross-sectional area of each molecule.}$$

The square root of the cross-sectional area of the molecule gives an approximate value for its width.

$$\sqrt{20.5 \times 10^{-16}} = 4.52 \times 10^{-8} \text{ cms approximate width of a molecule.}$$

These values indicate that the stearic acid molecule is about six times as long as it is wide.

The dimensions of the oleic acid molecule were determined in a similar manner. Because of the similar constitution of stearic acid, $C_{17}H_{35}COOH$, and oleic acid, $C_{17}H_{37}COOH$, their molecules might be expected to have about the same dimensions. Such, however, is not the case. The oleic acid molecule had a length of 11.7 Ångströms (a good check with Langmuir's 11.2 Ångströms). Its width was 6.7 Ångströms. A comparison of the dimensions of these two molecules shows that while the stearic molecule is over twice as long as the oleic, its width is considerably less. This must mean that while the stearic chain remains in a vertical position, the oleic double bond permits that molecule to double over like a horseshoe.

Thus, with simple apparatus and calculations, the invisible molecule has been magnified to such an extent that it has been possible to take its measure with so comparatively crude an instrument as the common meter stick. Though this method has already provided a fund of information, it is possible to utilize it for a still further deduction.

An examination of the formula of stearic acid, $C_{17}H_{35}COOH$, reveals that its chain contains twenty-one atoms or groups of atoms. This means that along the length of the chain, there should be twenty spaces in between the groups of atoms. Since the sizes of the atoms are negligible compared with the space between them, the division of the length of the molecule by 20 should give the length of one of the links in its chain, that is, the approximate distance between two of its carbon atoms.

$$\frac{27 \times 10^{-8}}{20} = 1.35 \times 10^{-8} \text{ cms vertical space between carbon atoms.}$$

This value is smaller than that of the space between carbon atoms in the diamond (1.54×10^{-8} cm), where the hardness of diamond would lead us to believe they are as close together as possible. Thus we conclude that the calculated distance is only the vertical component of an actually greater distance. The carbon atoms must therefore be arranged in a zig-zag order in the stearic chain.

It is satisfying to note that these results check with values obtained by other methods so that the assumptions made concerning the nature of the oil film are justified.

"Knowledge is the material with which genius builds her fabrics."

MODERN TECHNICS IN FIRST AID*

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SUGGESTIONS TO THE TEACHER

Accidents cause death to more than one hundred thousand persons each year in the United States. More than three hundred thousand people are totally disabled by accidents each year! At least five million injuries which require medical attention result from accidents each year! Many of the deaths, total disabilities, and much suffering could be avoided. Accidents occur less frequently, and as a rule are less severe, among persons trained in first aid. Such individuals are better able to recognize conditions that may cause an accident, and thereby are more likely to conduct themselves so that the accident will not occur. When accidents do occur, as they will, in spite of all precautions, it is important to know the proper thing to do if first aid measures are necessary. Frequently those injured are so situated that considerable time elapses before medical aid is secured. Therefore, it is for the individual's own welfare, as well as the good of his associates, that he have an adequate knowledge of first aid.

Specific Teaching Objectives

In beginning the teaching of this departure the following concepts might be emphasized:

1. First aid is the immediate, temporary treatment given in case of accident or sudden illness before the services of a physician can be secured.
2. One of the main purposes of first aid training is to prevent accidents.
3. Training in first aid equips the individual with sufficient knowledge to determine the approximate nature and extent of an injury.
4. The trained first aider is able to do the proper thing at the proper time when an accident occurs. Likewise, knowing what *not* to do is equally important.

Procedures

General first aid procedures which can hardly be overemphasized include:

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* Presented at the Biology section meeting of the C.A.S.M.T., Cleveland, Nov. 22, 1940.

1. Keep the patient lying down.
2. Look for hemorrage, stoppage of breathing; poisoning; wounds, burns, fractures, dislocation, snake bite, sunstroke, and any other possible emergencies which the nature of the accident might indicate. Be sure all the injuries are found.
3. Keep the patient warm.
4. Remember that if the patient is unconscious or semi-conscious following an accident, an injury to the head is usually the cause.
5. Send someone to call a physician or an ambulance. In calling, be prepared to give the following information:
   a. Location of injured person.
   b. Nature, cause, and probable extent of the injury.
   c. The supplies available at the scene of the accident.
   d. What first aid is being given.
6. Keep cool and do not be hurried into moving the injured person.
7. Never give an unconscious person water or other liquid.
8. Keep onlookers away from the injured.
9. Make the patient comfortable and cheer him in any way possible.
10. Be sure nothing is done that will cause further injury to the patient.

Suggested Pupil Materials

Preview

In some cases immediate first aid action saves a life. In all cases, proper first aid measures reduce suffering and place the patient in the physician's hands in a better condition to receive treatment. The duty of the first aider ends where the physician's begins.

Remember that prevention of accidents is far better than care after the damage is done.

Assignment and Discussion Outline

1. Definition and kinds of wounds.
   a. Abrasions
   b. Incised
   c. Lacerated
   d. Puncture
2. Infection of wounds
   a. Causes of infection
   b. Methods of avoiding infection
3. First aid treatment of wounds
   a. When bleeding is not severe
   b. With severe arterial bleeding
   c. With severe venous bleeding
4. Compresses and dressings
   a. Essential requirements

    b. Improvised dressings
    c. Care in handling
  5. Bandages
    a. Kinds and uses
      (1) Triangular
      (2) Gauze
      (3) Cravat
      (4) Four tailed
    b. General directions for application
  6. Shock
    a. Causes
    b. Results
    c. Prevention
    d. Symptoms
    e. First aid treatment
  7. Artificial respiration
    a. Standard technics
    b. Supplementary treatment
    c. Emergencies which may call for artificial respiration
      (1) Electric shock
      (2) Gas poisoning
      (3) Drowning
      (4) Choking
      (5) Hanging
      (6) Blows on head, neck, or "solar plexus"
      (7) When buried in "cave in"
  8. Fractures
    a. Simple
    b. Compound
    c. Symptoms
    d. Splints
    e. First aid treatment
  9. Injuries to joints and muscles
    a. Dislocations
    b. Sprains
    c. Strains
    d. Bruises
 10. Injuries due to heat and cold
    a. Burns
      (1) First degree
      (2) Second degree
      (3) Third degree
    b. Sunburn
    c. Chemical burns
    d. Sunstroke
    e. Heat exhaustion
    f. Frostbite
 11. Poisons and poisoning
    a. Prevention
    b. Symptoms
    c. Treatment
    d. Food poisoning
 12. Unconsciousness
    a. "Red" unconsciousness
    b. "Blue" unconsciousness
    c. "White" unconsciousness

    d. Causes of unconsciousness
        (1) Apoplexy
        (2) Alcoholism
        (3) Skull fracture and concussion
        (4) Shock
        (5) Hemorrage
        (6) Sunstroke
        (7) Heat exhaustion
        (8) Long exposure to cold
        (9) Poisonous drugs
        (10) Fainting
        (11) Epilepsy
        (12) Heart failure
13. Common emergencies
    a. Boils
    b. Blisters
    c. Corns
    d. Earache
    e. Hiccough
    f. Hives
    g. Foreign bodies in eye, ear, nose, throat, and stomach
    h. Insect bites
    i. Poison ivy

Suggested Questions for Discussion

1. What is first aid?
2. What are the main purposes of first aid training?
3. Where does the work of the first aider end?
4. What are the main points in the general care of a person following a serious accident?
5. What are the six most important points where pressure may be applied to check bleeding?
6. What precautions should be observed in applying a tourniquet?
7. What special treatment is indicated for a dirty wound which does not bleed freely?
8. What first aid treatment should be applied to a punctured wound?
9. What are the main points in first aid for the bite of a poisonous snake?
10. What are the symptoms and treatment of shock?
11. What is a compress or dressing?
12. How long should one work at artificial respiration before giving up the case?
13. What are the most important points to be observed in giving first aid to a simple fracture?
14. What are the chief symptoms of serious head injury and the most important points in first aid?
15. How should first aid be applied to a badly sprained ankle?
16. What are 1st, 2nd, and 3rd degree burns?
17. What are the most satisfactory home remedies for severe burns?
18. What are the main points in the prevention and treatment of sunburn?
19. What is the first aid treatment for poisoning cases?
20. How would you treat a case about to faint?
21. What symptoms are likely to indicate the beginning of appendicitis?

Special Projects

1. A committee of pupils might visit the local Red Cross Headquarters to obtain material for a report on the various first aid and life saving activities of that organization.
2. Some pupils whose fathers are employed in factories where unusual safety precautions are observed might report on such measures.
3. Pupils might report on first hand knowledge of accidents which involved the application, or lack of application, of first aid procedures.

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"COLD LIGHT" IN THE HOME

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The demonstration of cold-light has been a laboratory phenomenon for a number of years but the procedure below brings the subject to the home and proves fascinating entertainment to the scientifically minded.

The subject of cold-light, or as it is scientifically termed, chemiluminescence deals with the production of light without visible heat by certain substances in solution when these are treated with chemicals.

In an effort to explain the origin of the light of the firefly and other bioluminescent organisms, chemists have succeeded in producing similar light artificially in the laboratory. This study has led to the belief that such emissions of light are the result of oxidations which may be brought about by enzymes in animals or by electron shifts and the alteration of certain complex ring structures in plants.

The simple experiments outlined below can be performed by the ordinary layman. The only materials necessary are a few common chemicals, a few leguminous plants, tumblers, and a room capable of being completely darkened.

The chemicals needed are a small can of commercial lye, a ten-cent bottle of hydrogen peroxide and a small bottle of chlorox.

The substances to be oxidized by the above chemicals may be ordinary green peas, beans (green or dried), or peanuts. Even a small bottle of Almond Face or Honey Cream will suffice.

The solutions are made up as follows:

One-half teaspoonful of commercial lye is added to a tumbler of water and labeled as Solution-A.

In another glass pour two tablespoonfuls of hydrogen peroxide and add sufficient water to make a tumbler full of the mixture. This solution is labeled Solution-B.

One teaspoonful of chlorox is added to a tumbler of water and is labeled Solution-C.

Ordinary peas, beans or peanuts are then boiled separately for half an hour and the water solutions are cooled and kept for the experiment.

The performer then must select a room which can be completely darkened.

One-third of the tumbler containing Solution-A or lye solution is added to a colorless, empty pint jar or milk bottle. To this is added one-third tumbler of Solution-B or the hydrogen peroxide solution. Then two-thirds of a tumbler of the boiled water solution from the peas is added and the milk bottle or jar containing all three solutions is shaken carefully.

The lights are turned out and the observer counts to 25 to get his eyes adjusted.

After this is done the observer pours slowly into the above mixture one-half tumbler of the chlorox solution.

A glow immediately appears in the bottle which will last about three or four seconds.

Solutions obtained from beans and peanuts may be substituted for the peas and the variation in the emission of light noted for each material.

Should the experimenter have a bottle of Almond Cream he may produce light from this by placing a small amount in a dish and adding an equal amount of household ammonia and evaporating the mixture to dryness.

A brown skum is formed upon evaporation which may be boiled up in water solution or extracted with ordinary rubbing alcohol. This solution then may be used in place of solutions of beans, peas or peanuts and when treated as above with lye, hydrogen peroxide and chlorox solutions will emit light.

The experiment indicates the possibility of utilizing other ordinary substances as a source of lumination although the method does not produce an intense source of light. It also provides a fascinating way of showing differences between the legumes studied as well as a source of entertainment to the individual or group that is scientifically minded.

DIAGNOSIS AND REMEDIAL INSTRUCTION
IN MATHEMATICS

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There are many factors which have made it mandatory that teachers modify their instruction. The old textbook, recitation method of teaching is no longer accepted. In general, schools do not now hold up standards of attainment and fail to promote pupils on the basis of their failure to master certain predetermined units of instruction. All the children of all the people are now being promoted by age in heterogeneous groups. The trend is that the pupil shall no longer be held responsible for his failure to master the subject at hand, but rather that the teacher shall be held accountable for pupil success. The incentives of punishment and reward are no longer present. Children are not retained because of lack of subject content mastery. Instruction has become child centered rather than subject centered. We teach children—not facts. However, we must not only teach children but we must surely teach them something. Accepting the challenge that the school must adjust to the child rather than the child to the school, conscientious attempts are being made to manage instruction so that each individual pupil may profit most by the time spent in school. Teachers of the skill and content subjects probably feel this responsibility more than instructors in other fields of teaching.

In the effort to formulate a plan of instruction whereby each individual might progress at the optimum rate of speed, a four-year experiment was carried on under the direction of the author at the Training School of the University of Utah, Salt Lake City, Utah. The experimentation was confined to the fields of arithmetic and algebra. Instruction was individualized within the group. Identical plans of procedure were not followed with each class each year; however, the class organization which was generally used is here described. The usual plan of arranging experimental and control matched groups of pupils was followed.

In the experimental group, each student worked alone except for individual aid from the teacher. However, since no class recitations were held, the teacher was free the full hour to help and guide each student. The procedure for each individual pupil was as follows: Each student took a diagnostic pre-test to de-

termine whether or not the student needed work in that particular phase of arithmetic. If it was found that the pupil already possessed a mastery of that unit of work, the next pre-test was taken, and so on until the pupil found a weakness in his mathematical preparation. When a student failed a pre-test, remedial drill work was given and a final test given over the unit to determine whether or not mastery had been reached. Three additional tests equivalent to the pre-test were available. Thus, when a student failed the pre-test, he had the opportunity to drill and test three more times. Thus no pupil wasted time working on topics which he had previously mastered. Each student progressed at his own rate of speed and did not wait for the whole class to do all the work, nor did any pupil leave a topic until this part of the work was thoroughly mastered. Of course all pupils did not finish all units of work in the same time, but the teacher was free to spend all his time helping each individual pupil.

In the control group, the regular textbook lesson assignment recitation method was used. All students prepared the same lesson each day. About one-half of the period was spent in study and one-half of the period was spent in recitation. All students attempted to learn the same amount of material in the same time.

During the ten-week period between October 1, 1936 and December 10, 1936, the experimental group of twenty-eight seventh grade pupils advanced, on an average, 1.41 years in arithmetic while the control group advanced .40 of one year. During the next ten-week period, the two groups were interchanged and the experimental group gained .99 of one year while the control group lost .27 of one year. We may understand the loss in the control group when we consider that many of these pupils were carried far beyond the average of the group. Now when the old lock step textbook plan of teaching was used, the material failed to challenge their ability and they lost some of the skill they had attained. When pupils are carried beyond their future life experiences and the situation is changed to the point that a challenge is no longer present, some of the skill is certain to be lost. The loss was not due to the fact that the students had reached the limit of their ability, because in this second half of the experiment the experimental group began more than one-half year ahead of the control group and then advanced almost a full year. In order for the pupils in the control group to

continue to gain, it would have been necessary to continue to challenge the ability of each individual pupil.

A few pupils in the second experimental group attained a perfect arithmetic computational score on the test, missing only those examples which involved the principles of algebra. We could not expect to measure further gain of these pupils by the New Stanford Arithmetic Test, three forms of which were used to measure progress.

In the 1937–1938 experiment a seventh grade class of thirty-eight pupils made an average gain of 1.4 years in ten weeks. In this case at any rate, a class of thirty-eight pupils made as much progress per pupil as a similar class of twenty-eight pupils had made in the same amount of time.

There is one point concerning the permanency of diagnostic and remedial instruction which should be noted. The fifty-six seventh grade students who were in the 1936–1937 experiment took algebra in their eighth year of school receiving no arithmetic instruction during this time. At the end of their year of algebra their average grade level in arithmetic was 9.2. Thus, by the end of their eighth year of school these students had taken one year of algebra and stood at grade level 9.2 in arithmetic.

The 1938–1939 experiment in arithmetic was carried on in a somewhat different manner than the experiments of the previous two years. The controlled instructional period lasted one full year rather than ten weeks. It was found that some variety of practice materials was advisable in order to maintain interest. Students were taught how to locate supplementary drill material from various sources. The procedure of test-drill-test was followed until a satisfactory degree of mastery had been reached. During the year ending June 6, 1939 the gains of thirty-five seventh grade pupils ranged from 1.1 years to 4.0 years with an average gain of 2.6 years.

The thirty-eight pupils who entered the seventh grade of the Training School in the fall of 1937 were followed for three years until the completion of their course in algebra in 1939–1940. It was possible to obtain complete records for twenty-seven of these pupils during the three-year period. These twenty-seven pupils were in a class which was given the Columbia Research Bureau Algebra Test; Test 2; Form A Revised, on June 3, 1940. It was found that the average score of these pupils was slightly above the 95th percentile according to the standard norm for

public schools. The range was from the 39th percentile to the 99.9 percentile. One pupil received a score of 66 which corresponded to the 95th percentile for second year students in private schools.

With such exceptional and consistent results over a period of four years it seems quite evident that diagnostic and remedial individualized instruction is at least one very effective method of teaching mathematics.

DOES THE LAW $\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}$ HOLD FOR IMAGINARY NUMBERS? DOES IT HOLD AT ALL?

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1. The textbook point of view. To introduce the subject, let us begin with a *verbatim et literatim* citation from two textbooks, one a College Algebra (1937), p. 290, art. 163, the other a Trigonometry (1934), p. 166, art. 106. The verbal identity of both statements may be fairly explained by the circumstance that both books have in common one of their respective co-authors. The citation follows:

"*Operations with imaginary numbers.* It can be shown that, with proper definitions for combining imaginary numbers, they act like real numbers and obey all the laws of algebra, with the exception of the law

$$\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}.$$

This law is excepted because it conflicts with the definition of the unit of imaginaries, and a definition is always fundamental.

Thus, if this law did apply, we should have

$$\sqrt{-1}\cdot\sqrt{-1}=\sqrt{(-1)(-1)}=\sqrt{1}=1,$$

whereas, by definition, $\sqrt{-1}\cdot\sqrt{-1}=i^2=-1$.

It, therefore, contradicts the definition of the unit of imaginaries to say

$$\sqrt{-2}\cdot\sqrt{-3}=\sqrt{(-2)(-3)}=\sqrt{6}.$$

If the imaginary numbers are first put into the proper form, no trouble will occur.

Thus,

$$\sqrt{-2}\cdot\sqrt{-3}=\sqrt{2}\cdot i\cdot\sqrt{3}\cdot i=\sqrt{6}\cdot i^2=-\sqrt{6}.\text{''}$$

2. The equations $\sqrt{4}\cdot\sqrt{9}=\sqrt{36}$. We say "equations" (pl.) because $\sqrt{a}$ is two-valued and thus the above represents $2^3=8$ equations as corresponding to an *independent* choice of the values of the radicals

$$\sqrt{4}=\pm2, \quad \sqrt{9}=\pm3, \quad \sqrt{36}=\pm6.$$

Let us write down those eight equations and mark each one "right" or "wrong" according to its arithmetical contents:

$(+2)(+3) = +6$	right	
$(+2)(+3) = -6$		wrong
$(+2)(-3) = +6$		wrong
$(+2)(-3) = -6$	right	
$(-2)(+3) = +6$		wrong
$(-2)(+3) = -6$	right	
$(-2)(-3) = +6$	right	
$(-2)(-3) = -6$		wrong

(1)

Hence, out of the eight equations comprised symbolically in $\sqrt{4} \cdot \sqrt{9} = \sqrt{36}$, four are right and four are wrong.

3. *The equations* $\sqrt{-4} \cdot \sqrt{-9} = \sqrt{36}$. The values of the three radicals involved are

$$\sqrt{-4} = \pm 2i, \quad \sqrt{-9} = \pm 3i, \quad \sqrt{36} = \pm 6,$$

and the eight equations arising from the above are:

$(+2i)(+3i) = +6$		wrong
$(+2i)(+3i) = -6$	right	
$(+2i)(-3i) = +6$	right	
$(+2i)(-3i) = -6$		wrong
$(-2i)(+3i) = +6$	right	
$(-2i)(+3i) = -6$		wrong
$(-2i)(-3i) = +6$		wrong
$(-2i)(-3i) = -6$	right	

(2)

Hence, again out of the eight equations comprised symbolically in $\sqrt{-4}\cdot\sqrt{-9}=\sqrt{36}$ four are right and four are wrong.

4. *Criticism of the textbook point of view.* To show that $\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}$ "holds" for *real* roots, the texts would pick out some of the four *right* instances in (1). To discredit the law $\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}$ for *imaginary* roots, the texts picked out some of the four *wrong* instances in (2). This has nothing to do with the roots being real or imaginary, but is a consequence of the neglect to consider all the radicals involved as many-valued symbols.

5. *The equations* $\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}$. Considering the many-valuedness of the symbols involved, we should realize that the above is a symbolic comprehension of eight equations, four of which are right and four wrong, no matter whether the radicals are real, imaginary or complex.

6. *Concluding suggestion.* In teaching radicals, utmost emphasis ought to be put on their many-valuedness *before* starting formal operations. Using "i" as a one-valued symbol instead of the two-valued $\sqrt{-1}$, all ambiguity is removed. That use of i doubtless is meant in the expression "proper form" in the last example of the citation.

STUDIES OF GLOWING GASES MAY SOLVE AURORA PROBLEMS

By studying the glowing of gases in tubes after an electrical discharge has passed through them a better understanding may be obtained of the process by which gases in the atmosphere are made to glow in the northern lights, Dr. Joseph Kaplan, and S. M. Rubens, of the University of California at Los Angeles declared.

They described experiments with such afterglows, in mixtures of nitrogen with helium, neon and argon. In the nitrogen-helium mixture they obtained many of the so-called "forbidden" radiations of nitrogen. These are called forbidden because they cannot occur under normal conditions.

ELECTRIC IMPULSE IN ELECTRIC EEL TRAVELS HALF MILE PER SECOND

In the electric eel there is an electric impulse in the animal's electric organ which travels from tail to head at a speed of half a mile per second, or even more, the physicists were told by W. A. Rosenblith of the University of California at Los Angeles, and Richard T. Cox, of New York University. These speeds, faster than any recorded nerve impulse, though far below the speed of electricity itself, were previously suspected, and been confirmed by new measurements.

POWDERED METALS IN MODERN LIFE

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The art of powder metallurgy originated about the same time that chemistry became a science. The first metal to be processed by this method, that is, to be converted from the powder to the massive form, was platinum. Pure platinum powder was obtained by chemical precipitation and reduction, but when the platinum was heated to the fusion point, carbonaceous gases were absorbed and the metal became hard, brittle, and unworkable. It was found, however, that by heating the powder to a temperature several hundred degrees below the fusion point, then forging, the powder particles adhered. By repeated heating and forging operations, ductile platinum was obtained.

While the technique of powder metallurgy has been known for a long time, metallurgists still consider the art to be in the formative stage. Four contemporary developments in the field which have proved quite revolutionary and have surprised metallurgists by their performances include the production of:

a. Ductile refractory metals such as tungsten (melting point 3370°C.), tantalum (melting point 2850°C.), columbium (melting point 2500°C.), and molybdenum (melting point 2620°C.).

b. Porous metal bearings which are now widely used in the automotive industry.

c. Powder metal contacts and electrode materials which have greatly increased the effectiveness of welding machines, and the performance and safety of devices for interrupting electrical currents.

d. Hard cemented carbides which are responsible for the upward revision of wire drawing and metal working practice.

Industry has found that the process of powder metallurgy must be used when the following conditions prevail; (a) when the metal is too refractory to be melted conveniently because of the difficulty in obtaining high temperatures, in producing suitable refractories in which to carry out the fusion, and subsequent loss by oxidation and volatilization; (b) when the product is required to retain in given proportions the essential identity of each component: for example, the cemented carbides of tungsten, tantalum, and titanium must manifest the hardness of the carbide constituent and yet retain the toughness of the binder, cobalt or nickel; (c) when the structure is not obtainable by any

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other metallurgical method: for example, porous bronze bear-
ings cannot be made by melting or casting; and (d) when the
components of the desired product cannot be alloyed conven-
iently because of excessive spread in their melting points, or be-
cause of their immiscibility: for example, in the manufacture of
copper-tungsten and silver-tungsten composites for use as con-
tacts in electrical interrupting devices.

Powder metallurgy has certain advantages over other proc-
esses and its use is recommended when casting and forging are
difficult, and, as a result, powders become more economical. It is
also to be preferred when the usefulness of a product is increased
by its purity. Consequently, the need for deoxidizers and de-
gasifiers as in melting and casting is avoided.

PRODUCTION OF POWDERED METALS

Powder metals can be made by a number of methods. The se-
lection of the method depends on many factors such as the cost,
purity, and the properties of the metal.

1. *Machining* yields filings, turnings, and cuttings which are
usually by-products and serve as reducing agents. Dental alloy
powders, which are expensive, are usually made by this method
because the high cost of the product is not materially affected
by this expensive procedure.

2. *Milling* by stamp, ball, or attrition mills is used for metals
like antimony, bismuth, and brittle alloys. Chromium, man-
ganese, molybdenum, nickel, and titanium are powdered in ball
mills after a preliminary crushing. Malleable metals such as
copper or aluminum are converted into flaky powders by a
stamping or hammering process. This is done under some lubri-
cant which prevents the welding together of individual particles.
Metals that present an explosive danger such as aluminum or
magnesium are made by either the Hall or the Hametag process.
These processes powder coarse granules into fine powders by the
self grinding of the granules in two opposing streams of com-
pressed air. Copper flakes are used in the manufacture of com-
mutator brushes; aluminum powder is used for pryotechnics and
flares, and with liquid oxygen in explosives. The explosive,
ammonal, is a mixture of ammonium nitrate and aluminum
powder. The largest use is in the production of paints where it is
claimed a greater unit surface is obtained when the metal flakes
of copper or of aluminum are properly orientated in the film, to
give what amounts to a continuous metal coat. In printing inks,

aluminum powder is suspended in a suitable vehicle, and subsequent printing gives a continuous aluminum film on the paper.

3. The *shotting* process produces coarse, rough, spherical powders, and is applicable to metals which do not oxidize too readily in the air. The molten metal is allowed to pass through a screen or small orifices, solidifying in air, and dropping into water. Oxidizable metals are treated in an inert atmosphere. A little antimony is added to lead to increase the surface tension and to make nearly perfect spheres. Aluminum shot, thus prepared, is used for deoxidizing steel.

4. The *granulation* process produces coarse metal powders. This process involves the rapid stirring of a slowly cooling molten metal. The granules become coated with oxide. Aluminum, cadmium, and zinc are made by this method. Granulated aluminum is used in the Thermite process.

5. The *atomizing* process is used for metals with melting points lower than 700°C. The powder is produced by forcing a stream of molten metal through an orifice and striking this stream with a blast of air, steam, or gas. Rapid chilling prevents excessive oxidation. Exceptional care must be taken to avoid sparks in the preparation of powders by atomization, otherwise disastrous explosions will result. Aluminum, zinc, and tin produced in this manner are used for molding work. Mixtures of aluminum and copper powders with certain chemicals are contained in the pads which are used in setting permanent waves without electricity.

6. The *condensation* of metal vapors is a process used to produce very finely powdered zinc, iron and nickel. The distillation of zinc produces a very fine powder which is used for pigments. The carbonyls of iron and nickel are produced by allowing carbon monoxide to react with the metal powders at temperatures between 100° to 200°C. and pressures of 2000 to 3000 pounds per square inch. The carbonyls thus produced are decomposed between 150° and 400°C. in an atmosphere of nitrogen, and in a vessel whose walls are maintained at a low temperature. Alloy powders may be made by joint decomposition of mixed carbonyls. The powders produced in this manner are almost perfect spheres and vary in size from one to ten microns. The carbonyl method is used industrially for iron, nickel, and their alloys. Other metal powders can also be made by this method.

7. The *reduction* of metal compounds is used to prepare tungsten, cobalt, molybdenum, nickel and iron. Usually the oxides

are reduced in an atmosphere of hydrogen. Good control of powder size is possible since the size of the powdered metal depends on the size of the oxide particles. Tungsten produced in this manner is used for incandescent lamp filaments. Metallic powders are of higher purity when reduced with hydrogen rather than with carbon monoxide.

8. *Chemical precipitation* involves the displacement of one metal by another from solution. Tin, obtained from stannous chloride solution by displacement with zinc, is used for molding work; and silver, obtained from a silver nitrate solution by action with zinc, is mixed with copper and graphite to make molded electrical contacts.

9. *Electrolytic deposition* produces powdered metals when conditions are controlled rigidly. From an aqueous solution, copper, tin, silver, cadmium, and antimony are obtained as spongy deposits when a high current density is used. Thorium, columbium, and tantalum are obtained as fine powders upon electrolysis of fused fluoride salt baths.

10. By *sintering* together two metals, one of which has a high melting point and one a low melting point and by maintaining the temperature above the melting point of the low melting constituent, a diffusion of the latter throughout the mass of the high melting component occurs. The resulting mass can then be broken up into a powder. In this manner, master alloys of high melting elements can be made. Porous matrices of tungsten, molybdenum and chromium are placed in contact with molten copper which diffuses throughout the mass matrix. Examples of master alloys produced in this way are copper-tungsten, copper-molybdenum, and copper-chromium.

11. The *method* of *forming* an alloy and then *removing* one *constituent chemically* is employed when a very fine metal powder is desired, especially for catalytic work. A very fine nickel powder is obtained by alloying nickel with molten aluminum and then dissolving out the aluminum with a sodium hydroxide solution.

12. Extremely pyrophoric powders which must be stored in an inert atmosphere are produced by *amalgamation* and subsequently removing the mercury by distillation in hydrogen or in a vacuum. The rare earth metals, neodymium, cerium, and lanthanum have been made by this method.

PROCESSING OF POWDERED METALS

The processing of a metal powder to yield the ductile metal

involves the four steps of pressing, sintering, forming and swaging. The procedure described here for the production of ductile tungsten is typical. It can be applied to other metal powders such as tantalum, columbium, uranium, and thorium with few changes such as sintering temperature or applied pressure.

When tungsten of high purity is desired, the oxide is reduced by dry hydrogen. When reduced by carbon, the tungsten contains a little carbide together with the impurities contained in carbon. A reducing temperature greater than 950°C. can not be employed with carbon because carbide formation begins at this temperature. In the *pressing* operation the powder is pressed in steel dies under hydraulic pressure of 6 to 25 tons per square inch. The dies measure $\frac{1}{4} \times \frac{1}{4} \times 8$ to 24 inches in length. An 8-inch ingot of tungsten weighs 90g to 100g. Very fine powders can be handled successfully, but coarse powders need the addition of a volatile binder such as glycerine or water which is volatilized during the *sintering* operation. This operation is effected in an electric furnace in an atmosphere of hydrogen and at a temperature of 900°C. to 1050°C. The ingot obtained by sintering is porous, and non-crystalline. The bar has a density of 12 (60% the density of pure tungsten), and is too fragile to be worked. The *forming* operation produces an ingot which can be worked. In forming, the ingot is mounted between water cooled contacts, and a current of 1500 amps. at 10 volts is passed through it. At 1050°C., grain growth begins and is accompanied by shrinkage and the partial elimination of voids. The bar shrinks 17%, and the density increases to 17.5–18.5. The ingot at this stage is strong but very brittle, and has the appearance of a crystalline structure. The temperature is then raised to 1300°C. producing an ingot which can be worked and hammered. The ingot is now ready for the *swaging* operation which works it into a rod by a mechanical hammering process. The swaging machine contains two shaped hammers or dies which are rapidly rotated around the axis of the rod and forced together by cams so as to strike the rod. The swaging is started at 1300°C. for $\frac{1}{4}$-inch ingot which passes through 23 dies to give a wire of 0.8 mm. diameter at 750°C. Wires or sheets may be made by swaging. The production of wire is a continuation of swaging operation, and the production of sheet is started after a few swaging operations.

If the tungsten is to be used for lamp filaments, a little thorium nitrate is added to the tungstic oxide before reduction by hydrogen. The presence of thorium prohibits grain growth in

the tungsten filaments, and overcomes the off-setting difficulty
that occurs when the filament is used with alternating current.

Tantalum and columbium powders are obtained by the elec-
trolysis of fused fluoride baths. The powders are made into the
ductile metals by the same operations that are used for tungsten.
All the heating operations must be done in a vacuum furnace,
and the working operations performed at room temperature.
This is necessary because both of these metals absorb large vol-
umes of gases. Tantalum absorbs 740 times its own volume of
hydrogen. Use is made of this property to recover tantalum and
columbium scrap. The scrap is treated with hydrogen under
pressure and relatively low temperature. The hydrogen enters
the metal lattice and makes the metal brittle. Thus the scrap is
easily powdered by pounding, and the resulting powder is heat
treated in a vacuum to remove the hydrogen. New ingots are
made from this powder. The metal is used for corrosion resistant
equipment and as gas getters in high frequency vacuum tubes.

Uranium and thorium powders are also made by electrolysis
of fused fluoride baths. The uranium powder is used to make a
master alloy of nickel containing 66% uranium. The alloy is of
high density and is used to alloy with steel, nickel or copper in
molten state. Thorium powder is used to make X-ray targets,
sheets and wires. The thorium produced in this manner is duc-
tile and can be cold worked before annealing.

PorOUS Bronze Bearings

Porous bronze bearings, it is claimed, are indirectly responsi-
ble for the technological advances which have produced the
modern high compression automobile engine. The bearings are
made on a mass production basis by the automobile industry.
The advantages claimed for these bearings are numerous, the
most important being that: (a) they contain 25–40% by volume
of oil, and contain all the lubricant needed for its particular use;
(b) they supply all the lubricant needed at any speed with no
loss of oil by leakage or drippage; (c) they allow more oil to
come to the contact surface on heating, and to reabsorb it on
cooling; (d) they possess ductility and conform to irregular
shafts by force fitting; and (e) they are especially useful under
water, in inaccessible positions where oil neglect is expected, and
with dirty oil because the alloy acts as its own filter.

The bearing is composed of 90% copper and 10% tin and has
the same composition as cast bearings. Like cast bearings, they

may be alloyed with zinc, lead, 2% phosphorus-tin, and iron. The parent powders are usually prepared electrolytically, and are processed by the usual powder metallurgy techniques. At the sintering temperature, the tin melts and surrounds each copper particle with a thin film of molten metal which results in a rapid diffusion. The porosity is obtained by admixing certain constituents which volatilize during the sintering. As an example of this process, stearic acid is used. It not only volatilizes leaving cavities, but it also reduces the wear of the dies and permits the use of reduced pressures. The powder mixture is pressed hydraulically or mechanically at pressures of 15–25 tons/sq. in., and is heated first at 400°C. to melt the tin and cause diffusion, and then at 800°C. to bring about the final sintering. The total heating time is 10–60 minutes. The bearing is impregnated with oil by heating to 110°C. and quenching in oil.

COPPER-LEAD ALLOYS

Copper-lead bearings have replaced tin base alloys because their tensile and compressive strengths increase with temperature, their thermal conductivity is higher, their frictional coefficient is lower, and they require no hardened shaft. The bearings are especially desirable for heavy duty service. The alloys cannot be made by casting because of the differences in melting point and density of the metals. Although liquid mixtures with less than 38% lead are miscible, copper crystals separate out at 1083°C. to 954°C. (monotectic point) while the remaining lead solidifies at 327°C. Formerly, zirconium, sulfur, tellurium, and selenium were added to prevent segregation upon rapid cooling, but the results were not very good. Powder metallurgy stepped in and circumvented melting and casting, provided homogeniety, and gave a product with a higher lead content.

Powder metallurgists had no success by simply mixing copper and lead powders, because on sintering the lead melts at 327°C. and sinks to the bottom of the molds. To overcome this difficulty, 100 mesh lead shot is suspended in a cupric acetate solution and stirred until no copper is left in solution. The lead shot is thus obtained with a coating of copper. This powder is sintered in an atmosphere of hydrogen at 800°C., and the resulting alloy containing 45–55% lead can be worked and rolled. Composite bearings that are stronger are made with a copper backing and a copper-lead working face. Powders are used. Copper powder is placed on the bottom of the mold, and copper-lead alloy

shot on top. The mold is pressed, sintered, and worked by the usual technique. Copper-lead bearings in a phenol-aldehyde resin base have been reported recently.

HARD METAL ALLOYS

The interest in cemented cutting tools is best shown by the number of recent patents covering suitable cutting compounds, Some of the compounds patented are $W(C, B, Si)$,* $Ti(C, B. N, Si)$, $Ta(C, B, N, Si)$, $Cr(B, C, Si)$, ZrC, CbC, HfC and BN; these are bonded with a large variety of metals and alloys. If the various combination of two or more of the above compounds are considered, the possibilities are almost limitless.

A typical procedure for the production of a carbide is illustrated below. This technique can be extended to the others by suitably modifying conditions. The metal carbide in the form of a powder is made by heating a mixture of carbon and the metal oxide or metal for several hours at 1500–2400°C. The carbide powder is mixed intimately with a binding metal powder, usually copper or nickel, and the mixture is compressed in molds at pressures of 15 to 30 tons per sq. in. The initial sintering is done in an inert atmosphere, hydrogen, at 800–900°C. This gives the product sufficient strength for handling and forming. The final sintering is accomplished at higher temperature (1400–1600°C.) in hydrogen to effect diffusion of the components and to give a real alloying action.

The requirements of a hard tool material are: high melting point, simple crystalline structure of high symmetry, high thermal and electrical conductivity, and chemical stability under conditions of use. A high melting point is not important in itself for the tools are never used over 800°C., but hardness seems to be a concomitant of high melting compounds. The hardness is actually a function of the chemical attraction between atoms. A simple crystalline structure of high symmetry is desired to permit slippage without breakage.

The principle types used at the present time are sold under various trade names, but are composed of tungsten carbide, tantalum carbide, and titanium carbide combined with cobalt or nickel. Usually mixed carbides are employed. Two typical examples have the following composition:

1. 60% tungsten carbide—27% tantalum carbide—13% cobalt

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* W (C, B, Si) represents the three compounds tungsten carbide, tungsten boride, and tungsten silicate.

2. 61% tungsten carbide—32% titanium carbide—7% cobalt

The cemented carbides are used to cut stainless steel, and other high chromium alloys as Duralloy, Silichrome and Illium.

A tungsten-copper alloy suitable for welding electrodes and contacts is made in an interesting manner by powder metallurgy. Tungsten powder is pressed into an ingot and sintered to effect consolidation and strengthening. The ingot thus produced is porous. The porous ingot is heated in an atmosphere of hydrogen in contact with molten copper. The copper is drawn into the pores by capillary attraction producing a composite rod containing 40% copper. The tungsten matrix imparts high strength at high temperatures, and the copper gives the necessary high conductivity.

The examples given above illustrate the technical importance of the process of powder metallurgy. Modern industrial demands are so exacting that further extension of this technique seems highly probable. The recent establishment of a course in powder metallurgy at a well known eastern engineering school is evidence of the growing demand for trained operators in this field. Undoubtedly, investigation will open up still greater possibilities for this virgin and unchartered field of endeavor bordering both on metallurgy and chemistry.

TWO MEDALS AWARDED BY AMERICAN GEOGRAPHICAL SOCIETY

Two medals were awarded by the American Geographical Society to well-known American scientists, Dr. Robert Cushman Murphy of the American Museum of Natural History and Prof. Carl Ortwin Sauer of the University of California.

The award to Dr. Murphy was the Cullum Geographical Medal, given for distinguished work on the migrations and habits of oceanic birds, which are his specialty. He is the first ornithologist to receive this medal, which has previously been awarded 35 times. Earlier recipients have included Adm. Robert E. Peary, Sir John Murray and Prince Albert of Monaco.

Prof. Sauer received the Charles P. Daly Medal, in recognition of his outstanding contributions to geography, especially in the fields of land classification and land utilization. Among the 29 recipients of the Daly Medal have been such noted persons as Vilhjalmur Stefansson, Capt. Robert A. Bartlett and Dr. Roy Chapman Andrews.

MICROFILM EQUIPMENT FOR THE INDIVIDUAL WORKER

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The potential value of microfilm to the worker in the small school with limited library facilities can hardly be exaggerated. As interlibrary loans are limited in time, the worker often finds after he has kept a text the allowed time that he needs to consult the few pages studied intensively for an exact reference or for the exact wording of a difficult section. The worker can of course order microfilm of these pages from one of the various services; but delay, inertia and possible technicalities over copyright serve to lessen the value of these services to many workers. In addition, the need for copies of certain valuable original materials which the worker has borrowed (letters, prints, coins, etc.), and which he would hesitate to mail and many other projects may aid in prompting him to think of organizing equipment for the taking and reading of microfilm. The preceding hypothetical arguments were supplemented in the writer's own deliberations by two concrete situations: the desire to have on hand the historic papers of such physicists as Bohr, Rutherford, and Einstein and to carry out a small research problem which necessitated having on hand a paper on differential equations published in 1889. Microfilm was the easiest solution.

The commercial cameras for microfilm photography are expensive. The prices range from $50 for the outfit of an adapted miniature camera up. By combining equipment held in two departments we have been able to set up a Leica copying arrangement that gives microfilm with excellent definition. Although this equipment is highly satisfactory, we have realized that it would cost about $200 to be duplicated.

The essential precision requirements in a microfilm are lens, shutter and film advancing mechanism. For good work in color and black and white the lens should be of fairly wide aperture, astigmatic, achromatic and with good resolving power. A lens meeting these requirements could be ground, but there would be no saving in attempting such a tedious task. The possibility of finding among the numerous discontinued 35 mm moving picture cameras one that might be built into a precision microfilm camera seemed the more logical approach. No doubt there

are many that might be used. The writer found that the Sept, made in France, was once a popular and widely distributed 35 mm camera with a good f3.5 lens of 5 cm focal length, and a positive, ruggedly constructed film advance. The prices now asked for a Sept range from \$10 to \$25. The camera can be loaded with short strips of film for a few exposures and will hold a maximum of approximately 18 ft. of film—enough for 250 single frame 35 mm pictures.

The camera stand may be an adaptation of any enlarger stand or a modification of the stand described by V. E. Schmidt
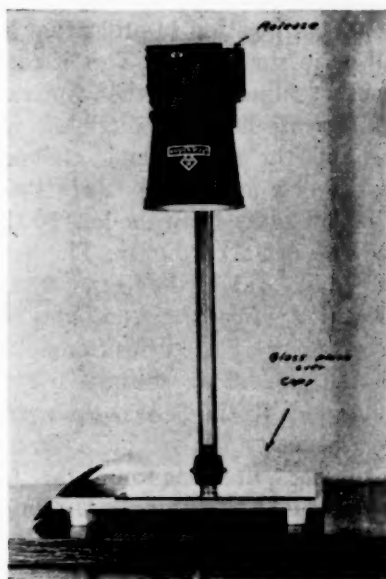
FIG. 1. The completed microfilm camera.

(SCHOOL SCIENCE AND MATHEMATICS, 40: 165, 1939). In our laboratory the lamphouse of a Praxidos enlarger was inverted, the lens house removed, and the camera mounted above with a strap. The lamphouse serves as a most efficient lens shade and does not vignette the picture, even when the lens is far off-center. Centering the camera over the material before loading is easily effected by putting a piece of tracing cloth in the film track, opening the small window in the back of the camera, and observing the image on the tracing cloth. A little margin should be allowed, so that when the camera is returned loaded there is less danger of cutting off the page. This stand will be

replaced soon, however, by a stronger four post assembly made of iron pipe.

The focusing was rendered precise by applying the simple lens formula $1/p + 1/q = 1/f$. It is possible to use this, for the Sept lens focuses as a unit and not by the separation of the lens elements. The procedure was to focus the camera carefully at 100 cm by using cards arranged in tiers. Trial films were run at full aperture and the negatives examined under a microscope. The image distances for 100, 90, . . . , 40 cm were calculated from the formula. For example for 100 cm the image distance is 5.27 cm; for 80 cm it is 5.33 cm. Thus we need to rack the lens out .06 cm from the 100 cm position in order that an object 80 cm from the lens will be in sharp focus. This is easily done with a mounted micrometer caliper, and the camera body may be marked with a thin white line. Although the writer has found this procedure reliable, he recommends that each of the distances be tested through actual exposures before the camera body is marked. The distance from the lens to the copy is easily measured and the lens set accordingly. The upright of the enlarger has a metal guide which prohibits lateral motion. If the base board is laid off in concentric rectangles so that each will be covered by the camera at fixed positions along the upright, the focusing and the placement of copy is greatly simplified.

The choice of speeds with the Sept is the most serious limitation. This can be remedied by mounting a salvaged shutter before the lens. Still the writer has found the instantaneous exposure (1/60 sec.) and P (bulb) sufficient. Using 3 no. 2 photoflood lamps to illuminate copy ($6\frac{1}{2} \times 9\frac{1}{2}$) the 1/60 exposure at f8 on Microfile film gives good negatives, hence Kodachrome can be exposed with the lens closed to about f16 with the same illumination. The instantaneous exposure could be increased by enlarging the opening in the rotary shutter.

The film stock available for microphotography includes several brands of positive film, Kodak Microfile panchromatic, Agfa Document, and Minnipan. The positive film should have should have an acetate base for it is not only safer than the nitrate but more durable. For colored objects, faded or stained copy the panchromatic film with suitable filters will give good printable negatives. The positive film costs about 2¢ a foot (16 single frame pictures), the panchromatic about 6¢. In developing, it is good practise to follow the manufacturer's recommendations. If positives are needed the negatives may be strip

printed on positive stock in a homemade or cheap commercial printer.

The inexpensive reader described in a previous note (SCHOOL SCIENCE AND MATHEMATICS, 40: 411, 1940) accommodates the microfilm from the Sept with satisfactory reading ease so long as the ratio of reduction is not large. A reduction of 1:10 is a fair limit although greater reduction is still legible for checking. By mounting the more valuable single frame pictures, wall projection up to 20 minutes in a small 50 watt film roll projector is possible. For this work, the front pressure plate of the projector is removed and slots filed in the sides. The pressure plate is replaced for the showing of film strips. The frames
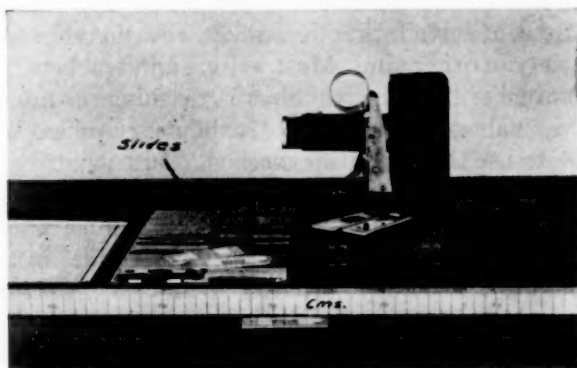
FIG. 2. The projector stands on its case. The tabs on the slides carry essential data.

are mounted in half of a 35 mm mask between 1″×3″ microscope slides and the slides are bound with Kodak slide binding tape at a total cost of $1\frac{1}{2}$¢. The resulting mountings are very durable and the slides are easily stored in a slide box with the wooden teeth removed. (This little projector serves excellently for projecting prepared slides in histology and bacteriology.)

The preceding apparatus (second-hand Sept camera $10, second-hand projector $7) has not only been an indispensable adjunct to the writer's work but is helping greatly in the preparation of film strips and slides for the visual education program in several departments. For example we make picturols in full color for approximately 6¢ a frame!

A HIGH SCHOOL CHEMISTRY COURSE BASED ON THE PRINCIPLES OF REFLECTIVE THINKING[1]

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1. INTRODUCTION AND PROBLEM

What special benefits result to a student from studying chemistry or other science? The aims or purposes of teaching science have been stated in a variety of ways. Emphasis has been placed on knowledge of principles, development of desirable habits, skills and attitudes, attainment of health, worthy use of leisure, development of certain practical skills, vocational preparation, and a variety of other aims. Most writers and teachers, however, agree that one of the principal aims in teaching science, and one of the chief values of studying it, is the development of ability to think—to use the "scientific method." Just what is meant by such terms as "scientific method," "scientific attitude," and "thinking"?

Noll gives an analysis of the scientific attitude[2] in which he says it involves accuracy, intellectual honesty, open-mindedness, the habit of looking for natural causes, the belief in the universal application of the law of cause and effect, suspended judgment, and the habit of criticism.

The "scientific method of thinking" may be said to consist of the following steps: (1) being faced with an obstacle which leads to the recognition that a problem exists, (2) locating and defining the problem, (3) formulating hypotheses which may serve as a basis for investigations, (4) collection and interpretation of data bearing on the problem, (5) testing the hypotheses, (6) generalizing—arriving at a tentative conclusion, (7) acting on the conclusion, using it in solving other problems.[3] This also represents the essentials of the process of "reflective thinking."[4]

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[1] An Abstract of a Thesis Submitted to the Department of Education of the University of Kansas in Partial Fulfillment of the Requirements for the Degree, Master of Arts, Summer, 1940.

[2] Noll, V. H., *Teaching of Science in Elementary and Secondary Schools*, New York, Longmans Green and Co.,1939. Chapter 2.

[3] Linn, George L., "A Sound Approach to Chemistry Teaching," *California Journal of Secondary Education*, vol. 10, November, 1935, pp. 492–496.

[4] Progressive Education Association, Committee on Secondary School Curriculum, *Science in General Education*, New York, D. Appleton Century Co., 1938, pp. 308–310.

Is Ability to Think an Outcome of Present Science Teaching?

Granting that the development of scientific habits of thought and scientific attitudes is an important aim in science teaching, are the methods of science teaching achieving that end?

A recent report of the Commission on the Secondary School Curriculum of the Progressive Education Association says that the present status of science teaching probably represents a mixture of the orthodox methods of the period from 1880 to 1910, and the later procedures introduced in the last twenty years.[5] General science and biology show later methods than do chemistry or physics.

Stone presents evidence from an experiment he performed with chemistry problems that only about 9% of students could think. Most of them merely memorized both facts and principles, and few could make use of their information in solving new problems.[6]

A recommendation of various research studies is that definite provision must be made to teach scientific attitudes. The assumption that they will be learned automatically, because of the nature of science material, seems to be without foundation.[7]

There are significant trends toward improvement in the matter of direct training toward developing scientific habits of thinking. Some of these trends are: (1) more use of the problem solving approach in teaching science, (2) testing in terms of the *objectives* of teaching, rather than testing for memory of facts only, (3) training students in the use of controls and variables in scientific experiments, and (4) helping students to develop scientific attitudes.[8]

The Viewpoint of the Present Study:

The development of the units in this study is based upon a philosophy of science teaching in keeping with a relativistic theory of teaching.[9] It is assumed, first, that the teaching program should be in keeping with the democratic conception.[10]

[5] Ibid., p. 13.

[6] Stone, H. W., "Do Students Think?", *Journal of Chemical Education*, vol. 13, pp. 316–317. July, 1936.

[7] Noll, V. H., *Op. cit.*, Chapter 3.

[8] Skewes, George J., "Trends in Instruction in High School Chemistry," *Secondary Education*, vol. 5, pp. 186–190. Sept., 1936.

Zechial, A. N., "Recent Trends in Revision of Science Curricula," *Educational Method*, vol. 16, pp. 402–407, May, 1937.

[9] Bayles, E. E., "The Relativity Principle as Applied to Teaching," *University of Kansas Bulletin of Education*, February, 1940, p. 7.

[10] Bayles, E. E., "Obligations of Teaching in a Democracy," *Journal of Educational Administration and Supervision*, April, 1939, pp. 251–259.

Indoctrination is avoided; the student is not "told" what to believe. Neither is he permitted to entertain *any* belief that his fancy or whim may fall upon, since this is not democratic, but individualistic. He should consider all the data which are pertinent, and reach conclusions that are in keeping with the data and with other conclusions which he accepts (this is known as "harmonization," internal consistency).[11] A teacher's obligation, if he is to teach democratically, is to promote a study of all sides of an issue, and to carry through such a study to a conclusion. This involves a technique of "problem raising," in which we seek points of inadequacy, vagueness, confusion, or conflict in a student's present views. The second phase of this process is that of "problem solving," in which we try to find ways to supply missing information, clarify the vague points, straighten out the confusions, and harmonize the conflicts. The teacher gives constant guidance to the student, trying to lead him to agree with data, and with other conclusions which he has accepted as valid—that is, to "agree with himself," not agree with the teacher merely because the teacher says it is so.

Secondly, the teaching program should be in keeping with a modern psychology. This means, (1) material which can be adequately handled on the intellectual level of the class—not too low nor yet too high a level; and (2) instruction which will promote *insight* or understanding, not merely memory.

It is assumed further that our objective in a democracy is to promote independent learning ability, and at the same time develop an enhanced and more harmonic outlook on life. Therefore, in the selection of the subject matter, we should choose units of study which represent challenging problems, the solution of which leads to general conclusions, which are recognized as tentative.[12] This assumes the use of the method of "reflective thinking," which involves sensing a challenging problem, considering several alternative solutions or conflicting views (hypotheses), amassing data, and arriving at a tentative conclusion which is most in harmony with the data and previous conclusions.

Many recent studies show a growing concern over the importance of teaching thinking and scientific method *directly*. but there is need for more studies, and more specific planning

[11] Bayles, E. E., "A Philosophy for Science Teaching," SCHOOL SCIENCE AND MATHEMATICS, December, 1939, pp. 805–811.

[12] Bayles, E. E., "A Philosophy for Science Teaching." SCHOOL SCIENCE AND MATHEMATICS, December, 1939, pp. 805–811.

of courses and procedures. This study makes an attempt in such a direction for a high school chemistry course.

Statement of the Problem:

In this study, two series of units making up high school chemistry courses are contrasted. One series is a set of units made up according to the Morrison plan,[13] and the other is a set constructed by the writer, using the principles of reflective thinking as a basis for the method of procedure. The "new set" includes certain minor changes in order of topics and content, but essentially the material is the same—the method of attack and emphasis are different.

A brief description of the Morrison viewpoint and type of organization is necessary, in order that the term "Morrison type unit" will be definitely understood. The meaning of learning to Morrison is the making of "personality adaptations," which are not the result of merely acquiring facts, but which come from acquiring *attitudes* of *understanding* or *appreciation*.[14] Morrison defines a *learning unit* as a "comprehensive and significant aspect of the environment, of an organized science, of an art, or of conduct, which being learned, results in an adaptation in personality."[15] He emphasizes *mastery*, which implies completeness. There are no degrees of mastery, either a student has or he has not mastered a unit. The Morrison technique emphasizes principles and their understanding.

The study of a unit in the Morrison plan involves a teaching cycle of steps somewhat as follows:

1. *Exploration*—pre-test to find out what is already known about the material.
2. *Presentation*—the understanding of major essentials of the unit, given by the teacher.
3. *Assimilation*—study and direct learning by the student. The mastery test would come after this step has gone on until it is believed that mastery is acquired. If necessary, re-teaching (re-presentation and more assimilation) may be done.

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[13] The Morrison units in chemistry are taken from a set formulated prior to 1930 by Dr. E. E. Bayles of the Education department, University of Kansas.

[14] Bayles, E. E., "Objectives of Teaching with Special Reference to the Morrison Theory," *Educational Administration and Supervision*, vol. 20, no. 8, p. 561, November, 1934.

[15] Morrison, H. C., *The Practise of Teaching in the Secondary School*, Chicago, University of Chicago Press, 1939.

4. *Organization*—outline, summary, bringing together and re-
lating of materials.

5. *Recitation*—the pupil presentation of his learning. Not in
the form of a test, but this part is supposed to be part of
the learning process.

In the Morrison units presented in this report, only the stu-
dent work sheets (to be used during the "Assimilation" step)
are included, as they are the parts which show the essential
organization of the units.

The problem, then, to be considered in this report is: What
are the differences, in terms of organization, of units of chem-
istry based on the Morrison plan and units based on the prin-
ciples of reflective thinking and a relativistic theory of teaching?

2. Presentation and Evaluation of Units

The order of presentation of the units is as follows: (1) the
Morrison type unit, (2) the reflective-thinking type unit which
corresponds in content to the Morrison type unit presented.
(3) After each set of units built on the two plans, comments
will be found regarding the more important differences and con-
trasts between the two types.

The content of the new type units sometimes varies a little
from that of the Morrison type. It was thought best, in order to

Unit	*Morrison Plan*	Unit	*Reflective Plan*
1	Chemical change	1	Chemistry and what it studies.
		2	Matter and chemical changes.
2	Solutions	3	Solutions.
3	Formulas	4	Symbols and Formulas.
4	Equations	5	Equations.
10	Periodic classification	6	How is matter made up?
7	Oxidation and reduction		
5	Ionization	7	Ionization.
6	Metals and non-metals	8	Metals and non-metals (Classification of Matter).
9	Commercial uses of nitro-gen compounds	9	Commercially important non-metals (sulfur and nitrogen).
8	Carbon compounds	10	Carbon compounds; organic compounds.

produce what the writer considers a more co-ordinated course, and meet better the peculiar demands of the new method, to change somewhat the order of the topics presented in the Morrison units. In one case, two of the new type units are equivalent to one of the Morrison type. In other cases, some of the topics covered in the old type are omitted in the new, or found partially treated in several units. The writer considers these differences minor ones, and hopes they may represent improvements.

The above table gives a list of the units in the two different plans, showing roughly what Morrison units correspond to the units of the new plan.

The detailed presentation of one set of the units follows, the units dealing with Solutions (the other units are omitted from this abstract, but are found in the original thesis). It should be remembered that, in the interests of brevity, not every detail of the class room procedure which would occur in the reflective type can be included. Often a condensed summary of the general trend of the discussion is given, and the necessity of a great deal more discussion and questioning around the main trend is implied. The written plans of the reflective units are intended as general condensed guides for the problem-raising and problem-solving phases of study, and would require considerable elaboration and extension when used with a class.

Unit II, Morrison Type
THE NATURE OF SOLUTIONS

I. How substances go into solution.
  1. Define the following terms: solvent, solute, solution.
  2. What is the most common solvent with which you are familiar? Is this solid, liquid or gas? Define each of the latter terms and give examples.
  3. Name several other solvents with which you have come into contact. Why will carbona remove grease spots from clothing when water will not?
  4. What forms of matter may act as solvents? Illustrate.
  5. If 5 cc. of sugar are dissolved in 50 cc. of water, will the total volume be 55 cc., or more or less? If 10 cc. of alcohol are added to 10 cc. water, will 20 cc. of the mixture be obtained, or more or less? Why is this?
  6. Must the solvent, to dissolve a substance, react chemically with the substance? Is the process of solution a chemical or physical change? Give reasons.
  7. Does the solute ever give evidence to the naked eye of its presence in the solvent? If so, tell when and give examples.

II. How solutions differ from suspensions.

  1. When one watches a suspension of fine dust particles or lampblack

(or other suitable material) that has been shaken up and then permitted to stand for a period of 5 to 10 minutes, what is found to occur?

2. Under the same conditions, what is seen to happen to a solution of sugar or potassium permanganate? What, then, is the first difference between suspensions and solutions?

3. If some lampblack and some potassium permanganate are each carefully placed in the bottom of separate vessels under water so as not to mix them with the water, and then permitted to stand for one or two days, what will have happened to each?

4. What is the second difference between solutions and suspensions? What name is given to this phenomenon? Can you suggest a reason for the tendency of the solid particles to move upward against gravity?

5. Compare the boiling points and freezing points of distilled water which contains a suspension of lampblack and distilled water in which sodium chloride has been dissolved. What do you find? Make a generalized statement as to the effect of the solute on the boiling and freezing point of the solvent. This is the third difference.

6. What is osmosis?

7. Using the osmosis apparatus, test out the osmotic effect of (a) sugar solution, and (b) a suspension of lampblack in distilled water. Which shows the effect? This is the fourth difference. Is there any evidence of the effect in the other case?

8. Run a suspension of lampblack through a filter. What is the result? Use a solution of potassium permanganate for this purpose. Result? This is the fifth difference.

9. What determines the limits of the amount of suspended matter that can be held by water in a vessel? How is this affected when the water is kept in constant motion? What is the relationship between the velocity of flow of a river and the amount of sediment carried? What effect does the chemical nature of the suspended matter have on the amount of suspended matter carried?

10. What determines the limit of the amount of solute a given solvent will hold? What effect does the nature of the solute have? Does the motion of the water affect this? Compare in detail with suspensions. Illustrate.

11. What effect does a change in temperature have on the solubility of the solute? Is this effect constant for all substances? Discuss and illustrate.

12. What is a saturated solution? A dilute solution? Distinguish between saturated and concentrated solutions.

13. Distinguish between saturation and super-saturation. Give examples of super-saturation.

14. Summarize this sixth difference between solutions and suspensions.

15. In a paragraph, summarize the differences in the characteristics of solutions and suspensions.

16. Why is it necessary that the solid salts, needed by plants for proper growth, be soluble in order to be used?

17. Why can a solution of table salt be used for a freezing mixture in order to freeze water or ice cream?

18. Why does a potato shrivel up when placed in salt water? How can it afterward be made to resume its former condition? Verify experimentally.

19. In city water supply systems, will filters remove suspended matter? Dissolved matter? Explain.
20. In salting pork for the purpose of preservation, it is possible to rub the salt on the outside of the piece, and to be assured that it will permeate the entire piece. Why is this so?

III. The nature of colloidal suspensions (often called colloidal solutions).

1. When starch is boiled up in water, the starch grains swell and burst, and let loose in the water very, very small particles of insoluble starch. This is known as a colloidal suspension. Make up 100–200 cc. of starch paste in this way and subject it to the six conditions indicated in Section II, and in tabular form show in what respects a colloidal suspension is like a true solution and in what ways like a suspension.
2. In addition to the above characteristics, colloids show some other properties that are rather striking. When very finely divided gold, which is insoluble, is suspended in water by means of an electric arc, it gives a ruby color instead of the gold color. Try to find other cases in which there is a change of color between colloidal suspensions and the solid state.
3. Under the ultra-microscope, colloidal suspensions show the brownian movement, which is shown by neither true solutions or suspensions. What is an ultra-microscope? What is the Brownian movement? What is its explanation? Why do neither true solutions or suspensions show it? What are molecules?
4. What is a "sol"? Describe the electric arc method of producing sols.
5. What is a gel? Give several common examples. Explain how gels are supposed to form.
6. What is a protective colloid? Give several common examples of the action of protective colloids.
7. So far, attention has been called to colloidal suspensions in liquids only. Solids and gases may also be the suspending medium. Classify the following as to the state of the suspending medium and also the suspended material: smoke, clouds, emulsions, ruby glass, fog.
8. Describe the adsorbing effect of colloidal particles. Why do colloids, such as starch paste, serve as good adhesives?
9. Explain the cleansing action of soap.
10. Explain how swellings of the body occur from bee stings or insect bites.
11. Explain the formation of deltas at river mouths.
12. Explain the deflocculating effect of gallotinic acid on graphite. What is the result of treating graphite with gallotinic acid?
13. Explain the action of the silver salts on a photographic film in producing a colloidal suspension of silver on the film after it has been developed.
14. Why does the application of manure to a soil greatly improve the condition of the soil, in addition to the addition of plant food?
15. Solutions, colloids, and suspensions are supposed to differ merely in size of particles. Discuss this difference, giving relative dimensions, and show how these differences will produce the different effects that actually are shown by the three different relationships between the suspending medium and the suspended matter.
16. Is there a distinct dividing line between solutions, colloids, and suspensions? Why?

17. Can it be said that any substance is absolutely insoluble? Are many substances soluble in all proportions? Illustrate.

IV. How dissolved substances are recovered from the solution.

1. Explain how some substances are recovered from the solution by precipitation. Give two examples.
2. What causes water to be hard? Distinguish between temporary and permanent hardness. Describe two large, and one small scale process for softening hard water. Indicate in each case whether the hardness is temporary or permanent.
3. What use can be made of distillation in recovering dissolved substances? Describe the process of distillation. Give examples.
4. "Fractional distillation" is the separation of a liquid solute from a liquid solvent. Describe how this is done. Give at least one practical example of a process which depends upon this principle.
5. Can a distillation process be used in separating a solute from a solid solvent? If so, give an example.
6. How can suspended matter be taken out of water on a large scale in a city water supply plant? Illustrate.
7. What is evaporation? How can this process be used as means to recover dissolved substances? How is it like the process of distillation?
8. When a liquid solvent is slowly evaporated from a solute until the solute is dry, the residue in the evaporating dish will usually be found to assume a crystalline form. What is a crystal? Name and describe several.
9. Distinguish between an amorphous substance and a crystalline substance. Give examples.
10. Which are crystalline in form, those substances that form true solutions or those that are colloidal? Which are amorphous in form? Illustrate. Explain the terms "crystalloid" and "colloid." Why are they opposites?
11. When the solubility of a substance in a given solvent is different at different temperatures, how can this property be utilized for the recovery of the substance?
12. How does the rapidity of evaporation of the solvent affect the size of the crystals which form? The shape?
13. What is the effect of pressure on the solubility of gases? Show how this is used in making carbonated water.
14. How can the phenomenon of supersaturation be used in making crystals? Will all soluble substances form supersaturated solutions?
15. What is a hydrated crystal? Give examples of hydrated and non-hydrated crystals. What is meant by water of crystallization or hydration?
16. Using copper sulfate as an example, cite the evidence which shows that hydrated crystals are really water solutions of the substance contained in the crystal.
17. Is the crystalline form of a substance a definite, non-changing characteristic of that substance? Give examples. How can the microscope be used to help identify samples of unknown substances? What is crystallography?
18. Define the terms efflorescent, deliquescent, hygroscopic, and give examples of each.
19. In a paragraph, summarize the methods that may be used to recover dissolved substances from solution, both on a large and a small scale.

20. Describe the method of obtaining salt from sea water. Of obtaining salt from mines by the solution process. Should cold or hot water be used for this purpose? (Look up the solubility of salt in cold and warm water.)

21. If a certain solution contained both sodium nitrate and sodium chloride, how might these two substances be recovered from the solvent, each in pure form, only slightly contaminated by the presence of the other substance?

References: Bradbury, Chapters 8 and 9; Brownlee, etc., Chapters 4 and 26. Laboratory exercises to be assigned.

Unit III, Reflective Type
SOLUTIONS

As a beginning to the study of the unit, the class reviews some of the important concepts already studied. They have already found what matter is, what its states are, what chemical and physical changes are, and how they differ, and they have worked out the contrasts between elements, compounds and mixtures.

They recall that in a mixture, two or more substances exist together, and there is apparently no change in make-up (no chemical change). Are all mixtures alike? They recall that some have compounds mixed together, some elements, some compounds and elements—that in some we have coarse pieces of matter, in others the matter is in a fine state of division.

Is the size of the particles the same in all mixtures? Evidently not. Can the individual particles be seen in mixtures, as the particles get finer and finer? They recall sulfur and iron powder mixed together. It was hard to pick out individual particles. One student recalls that some things were put in water and seemingly disappeared. Was this a chemical change? Was this a mixture? We call such combinations as this "solutions." Are solutions, then, mixtures?

It is decided to investigate the question, *What different results may we get by mixing things with water?*

The following experiments are performed:

1. Try equal amounts of the following in a test tube of water: potassium permanganate, chalk dust, charcoal, salt. Shake. Allow to settle. Repeat.

The words *solutions* and *suspension* are used to describe the different types of mixtures noted above.

What is one difference between a solution and a suspension?

If the above materials were left without shaking in the tubes for some time (a day or two) what difference would be noted? Does this suggest that particles have moved upward against gravity in some of the mixtures? In which ones? How could this be possible?

These questions are discussed, and tentative conclusions are accepted, as seem reasonable from the data preceding. Then further work is attempted in order to elaborate and test these conclusions.

2. What other properties (besides settling) will show a difference between solutions and suspensions?

Various suggestions are made, and such experiments as the following are tried out: passing of the mixtures through a filter, boiling and freezing points, densities. Try out the boiling point and freezing point of solutions of sugar, and of suspensions such as calcium carbonate.

The students are asked, "Can you state a possible general conclusion about the effect of dissolved substances on the boiling points and freezing points of water? How would increasing the amount of dissolved substance affect the boiling point? Freezing point? Devise an experiment to test out your conclusion. Carry it out." Other investigations might include an experiment on osmosis, with sugar solution inside the membrane, distilled water outside.

3. Could there be a form of mixture intermediate between suspension and solution?

(a) Try the experiments under section 2 above with starch paste (made by mixing a little corn starch with cold water to form a paste, then adding a small amount of this mixture to boiling water, and boiling mixture for a few minutes).

(b) Note differences in the behavior of this mixture and the solutions in section 1. *In what ways is this like a true solution?* The class will see such things as: particles do not settle on standing, do not pass through filter, etc.

In what ways is it different? Does not show osmosis effects, appears somewhat different, does not show expected influence on boiling and freezing points, etc.

What could be the cause of these differences in properties?

. It is explained that such mixtures in which particles do not settle are called *colloids*. What are some other colloids and their properties? (This question will be a reasonable one to investigate, if we are to get more data to help us to decide how to answer the question about the differences of colloids from true solutions, and what causes them.)

The following are selected as representative and interesting colloids to study: colloidal gold sol (directions for preparing these and others are found in Elder, *Lecture Experiments in Chemistry*, and various other sources), gelatin in water, emulsions such as milk, soap and kerosene, etc. Students are also asked to look up all examples they can find of colloids. They then classify the above materials as to state of suspending medium and also suspended material.

The terms *sol, gel, emulsion* are explained here, on the basis of the examples found in the experiments above.

4. From the previous laboratory studies, the following questions arise:

(a) What is the factor which determines whether a given mixture of substances will be a true solution, a suspension, or a colloid? If the observations regarding freezing and boiling point, filtering and osmosis, are accurate, what conclusions may be drawn?

Some factors to consider which might be of importance may be suggested here, by students or teacher: state of matter of the solute, whether it is element or compound, temperature, pressure, stirring, size of particles in the mixture. After critical examination of these proposals in the light of the experiments and reading done on colloids, it is seen that the only valid conclusion (the only one supported by the data) is:

The difference is due to size of particles.

(b) A question occurring here is: May the same substance exist sometimes in suspension or true solution, and other times as a colloid? (In the light of the conclusion accepted above, would this be possible?) It seems reasonable. Texts are consulted for data. Experiments are arranged, such as: showing colloidal and suspended sulfur, ferric hydroxide in ordinary and in colloidal form. This gives further evidence for our tentative conclusion, that the test of colloidal state is size of particles, and not necessarily the nature of material.

(c) From the nature of true solutions, what must be the size of particles

in a true solution? This question is discussed, and various hypotheses such as the following may be suggested and discussed:

(1) Size is *atomic*.

Consider this. Do substances break up into elements when dissolved? Is there evidence of chemical change in the process of dissolving? How may the original material be recovered from a solution? After answering these questions, it is seen that this hypothesis will not fit the facts.

(2) Size is too small to settle, but larger than molecules.

In considering this, the differences between colloids and true solutions are recalled, also the conclusion accepted to explain this difference. Which must have larger particles, colloids or true solutions? Cite evidence. Thus conclusions are drawn about the size of particles in both colloids and true solutions; that the colloids (not the true solutions) are clumps (groups) of molecules, not large enough to be dragged down by gravity; then the particles in true solutions are probably *molecules*. (It should be noted here that proteins or other large molecules have not yet been studied, and may constitute exceptions to this rule.)

From the above, the nature of solutions, suspensions, and colloids has been determined. Now a general answer is sought to the question: "How do solutions differ from other forms of mixtures?"

The class helps in formulating a definition of a solution, in the light of the experimental evidence. After many trials and refinements, something like this is considered acceptable: A solution is a uniform mixture of two or more substances in which the components may not be separated by standing or filtering.

In a similar manner, colloids and suspensions are defined.

What then is the fundamental difference? Again, it is seen that size of particle is the important thing. Are the proporties of mixtures—such as electrical conductivity, color, ability to pass through filters, or membranes, effects on boiling and freezing points of water, etc.—determined by the size of particles to a large extent?

A consideration of the foregoing conclusions will suggest that this is true, at least in mixtures in which water or other solvent plays a part. It is noted, then, that solutions and related mixtures discussed in this unit are very similar to other mixtures, in regard especially to absence of chemical union of their constituents, but that they are rather unique in some ways too, and this unique quality is due largely to the extremely small size of particles.

What other information is helpful in understanding solutions? A discussion of the problems met in the experiments above, as well as the reading, will probably bring out the need to study further, and form conclusions on additional questions, such as:

(1) How does temperature affect solubility?
(2) How does pressure affect solubility?
(3) Do solutions conduct electricity?
(4) What are other common solvents besides water? What substances insoluble in water dissolve in other things?
(5) Are solutions an aid in chemical reactions? Why?
(6) What common substances are soluble? Insoluble?
(7) Is there a limit to the solubility of a given substance in water? Why?

Some of these questions may be settled at this point by experiment and discussion. Others, such as numbers 3 and 5, will pave the way for interest in units to come, on ionization, reactions, etc.

COMPARISON OF UNITS ON SOLUTION

Morrison type

Reflective type

1. Starts with definitions of solution, solute, solvent.

1. Definitions are not presented, but materials are worked with, and by reasoning from data obtained, the student later works out his own definitions (with teacher's guidance).

2. Contrasts between suspension and solution are well brought out, but are not well integrated into the fundamental principle of difference, i.e., size of particle.

2. The contrasts between suspension and solution are studied, as in the Morrison type, but they emerge more definitely from the reasoning and suggestions of the class. These differences later are part of the data used to derive a generalization regarding the real cause underlying the difference.

3. Parts about solutions, suspensions and colloids are not well related or "tied up" to a common problem.

3. The study of all these comes out of the original question as to the different results of mixing things with water.

4. There is a great deal of emphasis on definitions of terms.

4. Terms come in as incidental to the solving of central problems,—a means to an end.

5. Covers more ground of factual text book information.

5. There is less emphasis on facts—fewer are directly considered, but they have a more vital relation to general conclusions.

6. Other hypotheses besides the accepted one are not considered; e.g., relative to the size of particles in solutions. (See question 15, part III.)

6. Other hypotheses are raised by the class, if possible, and considered. Each is eliminated or judged on the basis of experimental results plus agreement with previously accepted notions.

7. Unsolved issues or questions are not mentioned.

7. Unsolved or incompletely solved questions furnish an incentive for future units (see last part).

8. Class has no part in organizing questions and experiments.

8. Class is encouraged and expected to help formulate and plan questions and experiments.

3. Conclusions and Interpretations

The following are general conclusions regarding the contrasts between the two types of units:

(1) The principal characteristics of the Morrison type of organization seem to be: (a) Problems and study materials are defined for the student at the outset; there is no real "problem" in the sense of a "forked-road" situation. (b) There is more

expected from the unit, however, than mere fact retention; understandings and specific habits and skills are to be developed. But the idea of "mastery" would imply that every student was capable of arriving at the same understanding of the unit (completeness). In practical experience, this would seem to be an impossibility, and opposed to the principles of democratic teaching and the relativistic theory. The main ideal in teaching should be to develop *ability to form generalizations*, rather than merely to form a *given* generalization. (c) The Morrison unit does not tend to develop thinking on the "reflection level." (d) The conclusion of a unit is usually presented at the beginning in the Morrison type, while in the reflective type, the conclusion comes at the end, as a result of treating facts and data according to the scientific method. (e) Morrison units are isolated and self-contained, and do not bring out close relations between the various parts of the subject as much as they might. (f) Probably more facts and details of chemistry are treated in the Morrison type.

(2) The foregoing criticisms of the Morrison type have implied many of the characteristics of the reflective type of organization. These and other characteristics may be summarized as follows: (a) The student is urged and led toward a realization of need to define a problem ("problem-raising") and the value of solving it. (b) Students are encouraged to form many hypotheses, and are led into a process of reflective thought. They are not required in advance to accept a given explanation. The emphasis is on the *process* of scientific thinking, rather than on the particular facts, ideas and principles with which this process is dealing at the moment. (c) Generalizations and conclusions are considered tentative, always subject to further testing and revision. The aim is not arrival at an end-point of complete understanding, but the development of *greater* understanding and harmonization. (d) The facts and skills gained by this method will mean more to the student, since he will understand their derivation, true position and limitations. (e) Conclusions come at the end of units rather than at the beginning. (f) Conclusions suggest related problems and questions which are unsolved, and thus a natural connection is formed from one unit to the next.

(3) The foregoing conclusions suggest that a chemistry course, based upon the principles of reflective thinking, will aid in developing skill in using the scientific method, is better suited to

the psychological nature of the learning process, and is more in keeping with democratic ideals.

The writer realizes that a study of this type has many limitations, and testing, application, and further thinking about such a course as this will reveal needs for many revisions, eliminations, and additions. There is a definite need for the construction of tests which more adequately measure the chief goals and outcomes of teaching by this method. Most objective tests are largely suited to measuring factual knowledge rather than reflective thinking ability. Some work has been done in this direction, but more studies are needed.[16]

In conclusion, it is hoped that the development of such a course as here presented, and its analysis and comparison with common methods of presentation in use, will suggest similar lines of thought and study to other teachers and stimulate more critical examination and evaluation of present procedures in the light of whether they are accomplishing the most significant objectives we should strive for in a democratic system of education.

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[16] Progressive Education Association, *Science in General Education*, pp. 396–427. New York: D. Appleton Century Co., 1938.

THE LAW OF TANGENTS IN MODIFIED FORM AND SOME OTHER RELATED FORMULAS

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Let ABC be a triangle in which $c>a$. We add to the side $AB(=c)$ the segment $BE(=a)$. We subtract from the side AB the segment $DB(=a)$. Thus, $AE=c+a$ and $AD=c-a$. We join the points C and D and the points C and E.

Triangles BCD and BCE are isosceles triangles. We label the base angles ϕ and θ, respectively. We note that:

$$\phi = 90°-\theta, \quad \theta = (1/2)B, \quad DCE = 90°, \quad ADC = 90°+(1/2)B$$

$$ACD = 90° - [A+(1/2)B], \quad \text{and} \quad ACE = 180° - [A+(1/2)B].$$

We apply the Law of Sines to triangles ACE and ACD and obtain respectively:

$$\frac{c+a}{b} = \frac{\sin [A+(1/2)B]}{\sin (1/2)B} \tag{1}$$

$$\frac{c-a}{b} = \frac{\cos\,[A+(1/2)B]}{\cos\,(1/2)B} . \tag{2}$$

We divide (2) by (1) and obtain

$$\frac{c-a}{c+a} = \frac{\tan\,(1/2)B}{\tan\,[A+(1/2)B]} .$$

Thus,

$$\tan\,[A+(1/2)B] = \frac{c+a}{c-a}\,\tan\,(1/2)B \tag{3}$$

which is a modified Law of Tangents.
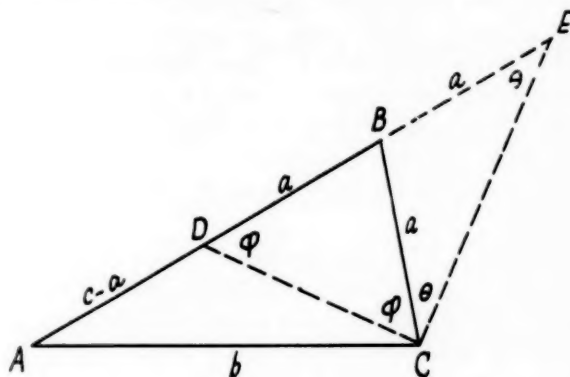
We apply the Law of Cosines to triangles ACD and ACE and obtain, since $CD = 2a\,\sin(1/2)B$ and $CE = 2a\,\cos(1/2)B$, respectively:

$$b^2 = (c-a)^2 + 4ac\,\sin^2\,(1/2)B \tag{4}$$

$$b^2 = (c+a)^2 - 4ac\,\cos\,(1/2)B. \tag{5}$$

Thus,

$$\sin\tfrac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}} \tag{6}$$

$$\cos\tfrac{1}{2}B = \sqrt{\frac{s(s-b)}{ac}} . \tag{7}$$

The Mollweide Formulas, (1) and (2), and the Law of Tangents, (3), come out in the usual forms if $90° - (1/2)A - (1/2)C$ is substituted for $(1/2)B$.

UNEXPLORED POSSIBILITIES OF INSTRUCTION IN GRAPHIC METHODS

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That the general public is "graph conscious" should be clear even to the casual observer. A nationally used commodity (a well known laundry product) has consistently been publicized by advertising copy which makes ingenious use of Neurath pictograph; so also, more recently, has the publicity of a widely used dairy product. And in one of the popular "movie" magazines not long ago, the professional career of a favorite motion picture star was graphically represented on a semilogarithmic chart which tacitly toned down the peaks of her popularity as expressed in terms of her salary! These instances are perhaps not the most edifying uses to which effective methods of visualizing quantitative data can be put, but they are indicative of the amazingly wide variety of application of graphic methods, and of the alacrity with which the lay public has accepted pictorial representation.

The implications for mathematical education should be at once apparent. Yet curiously enough, a considerable period of time elapsed before anything like adequate treatment of "graphics" was finally achieved; even then it had to force its way to recognition. The writer very well remembers his high school days with mathematics—he was brought up on Somerville's *Algebra* and Robbins' *Plane Geometry*. In those days (let us say before the World War) it was a rare algebra text in which more than a few apologetic pages were devoted to graphs, if indeed, they were mentioned at all; the treatment was generally limited to the graphs of a few simple algebraic polynomial functions. Not until the National Committee Report of 1923 appeared did the textbook writers pay significant attention to the matter of graphic representation. Gradually, although somewhat reluctantly at first, one book after another devoted an increased number of pages to this topic, until it became the conventional thing to include an entire chapter (or more) on "Graphs." During the next decade its popularity increased by leaps and bounds, due chiefly to the influence of general mathematics and the rise of the junior high school. Even today, although it has won the place that it deserves, its instructional possibilities have by no means been exhausted.

To discuss systematically and in some detail the many ramifications of graphic methods which might well be included in the mathematics of the junior and senior high school would unfortunately exceed the bounds of this paper. We shall therefore be content to offer a few brief comments, and conclude with a somewhat more extensive bibliography than usual, trusting that the latter will prove more useful to the teacher in search of source material and suggestive ideas.

Thus it would seem that greater use could be made of certain types of curves which rarely appear in secondary mathematics textbooks; as, for example, ogives, J-shaped and U-shaped distribution curves, Lorenz curves, Z-charts, "band charts," and S-shaped growth curves. Certain other graphic and statistical concepts might also appropriately be included, such as trend, cycle, periodicity, episode, seasonal variation, secular trend, moving average, extrapolation, and slope.

Another direction in which we might strike out is in connection with calculating charts, or various forms of nomographs. The treatment of these may begin with simple curves for formulas (this can be conveniently related to the function concept). The use of simple nomographs follows easily enough. It goes without saying, of course, that pupils are not to be taught how to construct nomographs, but merely how to use them intelligently. Even the introduction of the 100%-triangle may not be inappropriate material for instruction.

A third type of desirable content would deal with pictorial statistics, especially the Vienna method and the Neurath isotype. The reader who may wish to augment his familiarity with this phase of graphic representation will find Modley's *How to Use Pictorial Statistics* and Neurath's *Modern Man in the Making* two of the most helpful sources of information.

Still another fertile channel is the cultivation of critical attitudes towards graphs and their interpretation. Of chief importance in this connection are such considerations as optical illusions; "realistic" pictographs which misuse the principle of the 100% bar-chart; misleading effects due to the use of areas, or volumes drawn in perspective; fallacies or distortions arising from the use of "amputated" graphs or ambiguously indicated zero points; and false impressions given by using arithmetic charts instead of ratio (semilogarithmic) charts.

Finally, it would seem that a much wider selection of illustrative material could be drawn upon throughout the instruction

in graphic methods. This would enhance both utility and interest. The variety of applications of graphic representation is literally almost without end, and the practical everyday uses to which charts and graphs are put reach into many fields of interest to high school boys and girls—the physical sciences, history, economics, business, budgets and taxes, public health, government and civics, household problems vocational problems, shopwork, automechanics, radio, aviation, photography, handicrafts, and so on. The limitations are primarily those of the ingenuity, imagination, resourcefulness, and experience of the teacher. It is modestly hoped that the appended list of references will afford suggestive and stimulating leads.

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THE PLIGHT OF HIGH SCHOOL PHYSICS

*VII. Public Relations**

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The present article is the last of a series. Previous articles, barring the first, introductory one, have been specific discussions of problems inherent in the subject matter and in the teaching. The present discussion steps outside the classroom, at least in part, and considers the subject from a somewhat different point-of-view. Physics is seen to be in much the same position as would a commercial enterprise about to fail because its principal product needs improvement in order to meet modern competition and because its advertising policy has failed to keep abreast of recent trends. The problem of the management is furthermore aggravated by the fact that they feel they cannot make any very startling changes, either in product or publicity, lest they incur the displeasure of the principal stockholder. This principal stockholder, who acquired his control of the company during the latter part of the last century, is known to be constitutionally adverse to any sudden changes in production methods or in the character of the finished product.

PUBLICITY NEEDS

Paul R. Heyl, physicist of the U. S. Bureau of Standards, once told me this story. It seems that he was registering in order

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* This is the eighth, and final article of a series which has appeared in SCHOOL SCIENCE AND MATHE-
MATICS under the general title "The Plight of High School Physics." Reprints of the entire series may
be obtained by addressing the author.
Titles, and dates of publication of previous articles, are:

that he might vote in the Long Island village where he then dwelt. One of the questions asked him concerned his occupation. His reply, "physicist" suggested an occupation so unusual that the registry board proceeded to ask Heyl a great many questions concerning the meaning of the term and the nature of the work —so many questions that the explanation proved wearisome. Next year he knew better. This time when the question was asked him he replied, "chemist"—an answer which was accepted without comment.

The attitude of the registry board is, I take it, by no means unusual. Ask the average person what he understands by the term *chemist* and he will probably paint a word-picture of a romantic rubber-aproned individual who, working amid a labyrinth of flasks, condensers, glass-tubing, and beakers (many of them filled with highly colored and bubbling liquids which steam in the most spectacular fashion), is able to make all kinds of interesting and useful substances from almost anything that comes to hand—a modern alchemist, intellectually respectable because of his scientific investiture. A romantic figure, indeed! Ask Mr. Average Man what he understands by the word, *physicist*, and the reply is quite different—a weak and vaguely vulgar attempt at a joke or an identification of the physicist with a man engaged in very precise and rather dull measurement of some sort or other. An unromantic figure, indeed!

It is not hard to seek out the causes for the colorful connotation which the word *chemist* has for the general public. The last World War taught us his importance in connection with such necessities as dyes, fertilizers, poison gases, and explosives. The development of new substances of many sorts—of synthetic rubber, of Nylon, of a new binder for the safety-glass sandwich, of gasoline made from coal—have kept the term vividly before the attention of the public in recent years. Gradually the word has been extended in general usage to cover a wide range of activities considerably beyond the scope suggested by the term itself. Anyone, be he engaged in chemical research, or working at some detail of the applied phases of the subject, is dubbed a chemist.

The same is evidently not true in physics. We have already commented on one of the meanings which attach to the term *physicist*—that of a research scientist. But what of the applied phases of the subject? Is the word physicist used there? Evidently not. Applied physics is engineering, but the connection

between the two is rarely made by the average person. This is not to be taken to be a plea that we teachers should attempt to effect a substitution of the term *physicist* for that of *engineer* in our everyday speech. This condition does provide the basis for a criticism of teaching practice, and for some suggestions for changes in that practice.

Evidently one thing that physics teachers should do is to make clear this connection between physics and engineering. Our students should come to see that among the engineers who work on the Grand Coulee Dam are those who know a great deal about the strength of materials and about the forces exerted by impounded water, that the engineers who build the new high-tension transmission systems must be experts in the field of electricity, that the building of a modern theater, office building, or church, calls upon the services of experts in the field of heat, light, and sound. These students should understand, at least in a general way, the relation between physics and the various engineering fields—civil, mechanical, electrical, lighting, acoustical, aviation.

But in our attempts to place our subject in a better light, merely to make clear the relationship between physics and engineering is not enough. In addition, our students should appreciate the contribution of the engineer, as a worker in applied physics, to modern living. Just as the chemist is opening up new vistas through his discovery and synthesis of new substances, so are workers in the field of physics—engineers, inventors, research scientists—effecting profound changes in modern life through the building of new roads, the running of new power lines, the perfecting of air-conditioning and television, the production of new and more efficient devices, in several fields, for the effecting of energy transformations. Along side the romantic figure of the chemist working in his laboratory we may place the no less romantic figure of the engineer (i.e. the applied physicist), as builder and explorer working to extend the benefits of civilization to new areas of human living.[1]

Two cautions should be noted in connection with such a process. We should beware of over-romanticizing, of painting a pic-

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[1] An interesting example of the conditions for the correction of which this paragraph is pleading, is afforded by the New York Fair which closed last October. DuPont cries, "Better Things for Better Living Through Chemistry." Several othe rexhibitors—Eastman, General Motors, Ford—attest to the importance of the chemist. But rarely, if at all, is the physicist, or the subject, physics, mentioned. Instead, all of the startling developments shown in the General Electric and Westinghouse exhibits are credited to their "engineers."

ture of the life of an engineer, or of a research scientist, the like of which exists nowheres on earth. We are trying to develop appreciations of the contribution of physics to modern life—not to portray a type of motion picture hero for the delectation of the feminine members of the class or as a lure which will induce all the male members to become engineers themselves. Secondly, we should beware of setting up unique areas of separation where none exist in practice. In the solving of almost any technical problem, be it the building of a George Washington Bridge, the successful development of television, or the production of Nylon, the services of a large number of scientists from several fields are almost sure to be involved. Illustrative of this fact are the many researches that have been made in the field of atomic science. Often incorrectly associated by the lay public with a single field, chemistry, or less often, physics, contributions to our knowledge of the atom have been made by scientists working in both these fields and even in such a seemingly remote field as astronomy. A few years ago, Professor Urey of Columbia University was awarded the Nobel Prize for his work on heavy hydrogen. News of the award reached him some little time before the recept of the official notice. During this period, the scientist found himself in the peculiar position where he knew that he had won the coveted honor but did not know whether the award had been made in chemistry, or in physics. His work was of such a character that the award could have been made with equal logic in either field.

The high school physics teacher should, then, take every opportunity to improve the standing of the subject in the mind of his own pupils. An evident next step is to improve its reputation with other students, teachers, and parents. Improvements in our methods of teaching, possibly along the lines suggested in earlier articles in the series will gradually give the subject a better "press." But, as the business world knows, the possession of a good product is not enough. It also needs good advertising. The failure of the individual physics teacher to see this need is understandable. Organizations of physics teachers have been equally blind. A number of years ago, I learned of a meeting of the American Association of Physics Teachers, a college teachers organization, to be held in the city of Washington, at which meeting methods for the popularization of physics were to be discussed. Eagerly I travelled to the capital city—only to learn that the only steps contemplated were the establishment of a

magazine which would survey research and other recent devel-
opments in physics for the benefit of the research specialist in
all fields of science, and the creation of a sort of bureau which
would make it easier for college groups to obtain visiting foreign
scientists as speakers before science colloquiums and seminars.
And this at a time when the American Chemical Society was
doing an excellent job of popularizing chemistry through its
magazine *The Journal of Chemical Education!*

But what may the individual teacher do to secure this better
"press"? A number of things suggest themselves. The class may
put on a physics fair, or open house, at which interesting ex-
periments are demonstrated by students, exhibits are displayed,
talks are given, motion pictures are shown. Such a program
might run for an afternoon and an evening, at which latter time
parents would be invited. If this meeting can be dove-tailed into
a meeting of the parent-teacher association, so much the better.
Or the class may produce a play dealing with science in some
fashion, possibly one which deals with the historical develop-
ment of the subject—preferably written by students.[2] Insofar as
possible such plays should feature scientific experiments and
demonstrations, or effects based upon scientific phenomena.
However, elaborate procedures are not always necessary, and
successful assembly programs which will challenge and interest
the student body may often be whipped together in a short
time by having individual students, or small groups, prepare and
perform experiments suitable for such occasions. The presenta-
tion of such a program may easily require the services of an
entire class. Its presentation, or the production of a play, or
physics fair, as previouly suggested, may serve to bring out un-
suspected abilities and interests in individual pupils. Since such
outcomes are among the desired outcomes of our laboratory
work (See "The Languishing Laboratory," SCHOOL SCIENCE
AND MATHEMATICS 40: 457–62; 1940 (May)) we do not hesitate
to devote a certain amount of regular class time to such work.
Speakers who will give an interesting talk on topics associated
with physics may often be obtained from such organizations as
the General Electric Co., General Motors, the local telephone
company, or from some other local industry. A number of mo-

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[2] Among the plays, written and produced by students, which have been developed in the writer's
classes have been ones dealing with the end of the world, the Galvani-Volta controversy, the historical
development of our knowledge of electricity, and with alchemy. This last, probably the best of the
group, but not dealing with physics material appeared in the November (1940) issue of *Science Educa-
tion* (p. 315) under the title "The Fabulous Quest."

tion pictures of a general scientific character, and suitable for presentation in assembly, may be obtained either free, or at relatively low rentals.[3] The sponsorship of programs of these latter two types may well be a class activity carried out by a small committee therefrom.

THE PRINCIPAL STOCKHOLDER

Admittedly bad has been the repute of physics with students and general public. Equally bad, or perhaps unfortunate is a better term, has been the relationship between the subject (including its practitioners, the teachers) and the various control and standardizing agencies—the "principal stockholder." We should add that the situation is probably no whit worse with physics than with other subjects. In "Mismanaged Mathematics" (SCHOOL SCIENCE AND MATHEMATICS 40: 368–76; 1940 (Apr.)) we noted the effect that the setting up of college entrance standards has had upon the character of the subject, notably in its use of mathematics. Such standardizing and control agencies as the College Entrance Examination Board and the various state agencies (e.g. the Board of Regents in New York State) have undoubtedly had the beneficial effect of tending to raise the standards of the poorer schools. In other ways their establishment has been most unfortunate, perhaps nowhere worse than in their effect upon teacher psychology and morale. Yet, if we turn to the C.E.E.B. syllabus in physics we find little that confirms the general notion that the course is almost completely prescribed. The proposed revision of the requirements for the college entrance examination in physics (SCHOOL SCIENCE AND MATHEMATICS 40: 686–90; 1940 (Oct.)) divides its syllabus into two parts—a part from which questions will be asked and another part containing material suggested "as subject matter . . . which it is desirable to include for the enrichment of a well-balanced course but questions (on which) . . . will not appear." In another portion of the article there appears "The arrangement of the syllabus does not imply a teaching sequence." I consider even this revised syllabus far from ideal, but still I take it that there is nothing in this document that makes impossible such a reorganization of the subject as is suggested in the article "Water-Tight Compartments."

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[3] The best single descriptive list of films is the *Educational Film Catalog*, cumulative and classified according to the Dewey Decmial system, published by the H. W. Wilson Co., 950 University Ave., New York City. A smaller, but less expensive list is *1001* (75¢) an annual list published by *The Educational Screen*, 64 East Lake Street, Chicago.

Neither do I believe that the wording of this proposed revision concerning laboratory work makes impossible the type of laboratory work discussed in the article previously referred to, when the revision commission states that:

> In order that the objectives of the course of study may be fully realized, it is essential that the study of physics be accompanied by individual laboratory work as well as by class demonstrations. The laboratory work should occupy approximately one-third of the time devoted to physics and it should continue throughout the whole course. A list of experiments is not submitted as it is believed that the experiments will need to be varied according to the facilities of a particular institution.

And yet the retort of all too many teachers to almost any suggestion of change in their teaching procedure is that it can't be done, "The colleges won't let you," *or* "If we try this, my students will not be able to pass the C.E.E.B. examinations." My own teaching experience would tend to refute both of these statements. In addition, as an occasional member of the committee engaged in preparing the Regents examination in physics, along with the other members of the committee, I have experienced the very real difficulty in developing new and different questions that is occasioned by the restricted nature of the N. Y. state syllabus in physics. Someone has said that if Hitler had not had the Jewish people at hand as a scapegoat for the ills of the German nation, he would have had to invent them. Similarly, I suspect, that however much these standardizing agencies may genuinely handicap some teachers in their efforts to improve the teaching of their subject, there are others who, if these agencies had not been ready at hand as alibis for their own inertia would have had to invent them. Let us cease paying so much attention to those things which we say are hampering our progress and instead devoted our energies to preparing the best curriculum in physics that we can and, having done so, to doing the best job of teaching it that we can. The control agencies are almost sure to cooperate in any experiment which promises to furnish some relief for the sorry plight of high school physics.

A SUN-LAMP FOR POULTRY

A new sun-lamp has been especially devised for poultry farmers. One unit can supply the needs for 100 to 150 birds, exposing them for about 4 hours daily. Increased egg production, stronger shells, increased vitamin D content of the yolk and elmination of rickets are features that are claimed for the use of the lamps.

A NOTE ON PARAMETRIC EQUATIONS

CECIL B. READ

University of Wichita, Wichita, Kansas

Almost every elementary text book in analytic geometry devotes some space to the discussion of parametric equations. In some cases treatment is restricted to the discussion of a very few standard curves as for example, the cycloid, the ellipse, and the involute of the circle. In other cases attempt is made to show the relationship between the parametric equations of a curve and the corresponding Cartesian or coordinate equation.

Unfortunately many authors fail to make it clear that there may be various parametric equations for the same curve, in fact some texts leave the distinct impression that the obtaining of parametric equations is a unique process.

Again, in discussing the obtaining of the retangular or coordinate equation from the parametric equations several authors merely make the statement that this requires the elimination of the parameter without pointing out that this elimination may be extremely difficult, frequently not advisable, and sometimes impossible.

Perhaps of even greater importance is the failure to point out the possibility that the graph given by the parametric equations may be only a part of the graph of the coordinate equation obtained by eliminating the parameter. As a trivial example: the graph of the parametric equations $x = \sin^2 t$; $y = \sin^2 t$ is a line segment restricted to the first quadrant while the graph of the corresponding Cartesian equation is a line unlimited in extent.

As a matter of curiosity, thirty-five texts of more or less recent date were examined with reference to their treatment of this phase of the subject. Three failed to mention parametric equations. Thirty-two treat the topic in more or less detail, but of these only four mention the fact that the parametric equation may represent only a portion of the curve. Among these four, two seem to be in apparent disagreement as is evidenced by the following quotations:

"If we prove that every (x, y)-pair satisfying two parametric equations also satisfies a certain Cartesian equation, it does not follow conversely that every pair satisfying the Cartesian equation must satisfy the parametric equation."

"To find the coordinate equation eliminate the parameter ϕ between the parametric equations. Let the result be (2) $f(x, y) = 0$. This equation, being a consequence of the parametric equations, is satisfied by the coordinates

of any point on the curve. If, conversely, for every pair of values (x, y) satisfying (2) a value of ϕ can be found such that $x = f_1\phi$, $y = f_2(\phi)$, then (2) is the coordinate equation of the curve."

From this it would appear that one author assumes that the rectangular and the parametric forms of representation are essentially equivalent, but does not contend that the parametric form necessarily gives the entire curve. Another author apparently takes the point of view that unless the two forms do give identical portions or unless either form gives the entire graph they are not equivalent.

Even from the point of view of brevity, the omission of the points briefly summarized would seem a rather questionable practice especially in view of the fact that all could at least be mentioned in less than half a page. With no particular mathematical maturity required to understand a concept, one wonders why a text should run the risk of leaving a false impression.

AUTOMATIC HEADLIGHT CONTROL FOR AUTOMOBILES

BENJ. JOHNSON
Dodge Institute, Valparaiso, Indiana

Many times while driving an automobile at night on slippery roads or curves, I have wished for some method of headlight
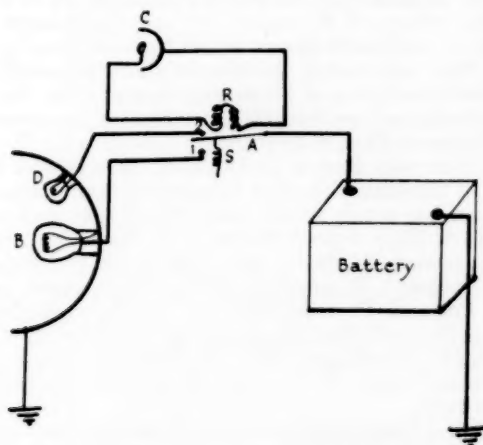
control that would not involve the use of my hands or feet. I need both hands for steering the car and my feet for clutch and

brakes in case of the necessity of a quick stop or deceleration in speed. With this in mind, I propose the use of a photoelectric cell and relay to solve the problem.

The photoelectric or photronic cell should be mounted somewhere in the front of the automobile where it will be affected most by the light from an approaching auto. A lens may be mounted in front of the cell to focus light on the sensitive photoelectric material of the cell.

When no light is on the cell C, the relay arm A is pulled by spring S against contact point 1. This closes the circuit from the battery to the bright headlight bulb B. If another automobile is approaching this car, the light from its headlamps will shine upon cell C. This causes a current of electricity to flow through the electromagnets in relay R and arm A is drawn to contact point 2. The battery is now connected directly to the dim light bulb D and hence, the headlight is automatically dimmed. After the car has passed the cell is again in darkness, and no current passes through it or through the relay. The electromagnets lose their strength and spring S again pulls arm A to contact point 1 and the light is again on bright.

PROFESSOR N. HENRY BLACK HONORED

BURTON L. CUSHING, *East Boston High School*

Professor N. Henry Black, one of the truly great physics teachers of all time, recently retired from the Physics Department at Harvard University. On the evening of November 22, sixty-six friends of Professor Black gave him a testimonial dinner at the Harvard Faculty Club, Cambridge, Mass. They represented the New England Biological Association, the New England Association of Chemistry Teachers, the Harvard Graduate School of Education, and the Harvard Physics Department, and the Eastern Association of Physics Teachers.

The toast master was Burton L. Cushing, East Boston High School, and the Harvard Graduate School of Education. Appreciation of the long and helpful teaching career of Professor Black was expressed by Mr. Ralph Bean, Girls High School, Boston, for the biology teachers, Mr. William Obear, Somerville, Mass. High School, for the physics teachers, Mr. Theodore Sargeant, Swampscott, Mass. High School, for the chemistry teachers, Professor F. A. Saunders for the Harvard Physics Department, and Dr. Bancroft Beatley, president of Simmons College, as a former student and teaching associate of Professor Black. A letter was read from President James B. Conant, of Harvard University who was unable to be present.

A fluorescent desk lamp was presented to Professor Black as an appropriate gift representing one of the latest developments in his chosen field of physics.

Professor Black entertained the gathering with an interesting talk on his experiences in over forty years of teaching.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-Sixth Meeting

BOSTON UNIVERSITY

Boston, Massachusetts

Saturday, December 7, 1940

MORNING PROGRAM

A Joint Session with

The New England Biological Association

and

The New England Association of Chemistry Teachers

Jacob Sleeper Hall, 688 Boylston Street

10:30   Address of Welcome: Dr. Norton A. Kent, Head of Physics Department, Boston University.
10:45   Address: The National Roster of Scientific and Specialized Personnel: Dr. Leonard Carmichael, President, Tufts College.
11:30   Address: Seismology and its Applications: The Reverend Daniel J. Linehan, S.J., Head of Seismology Department, Weston College.
 1:00   Luncheon: Announcement of arrangements will be made at the meeting.

AFTERNOON PROGRAM

Room 308, Sodden Building, Exeter Street

 2:30   Meeting of Executive Committee.
 2:45   Business Meeting.
        Report of Committees.
        New Books and Magazine Literature,
                Mr. Richard Porter-Boyer, *Chairman.*
        New Apparatus,
                Dr. Andrew Longacre, *Chairman.*
        Syllabus Revision Committee,
                Mr. Fred Miller, *Chairman.*
        Committee for Study of Physics Enrollment in Schools,
                Mr. Charles B. Harrington, *Chairman.*
 3:15   Address: The Training of Young Men for National Defense Work.
        Mr. Francis C. Crotty.

OFFICERS

President: John P. Brennan, High School, Somerville, Massachusetts.
Vice-President: John L. Clark, Chapman Technical High School, New London, Connecticut.
Secretary: Carl W. Staples, Chelsea High School, Chelsea, Massachusetts.
Treasurer: Preston W. Smith, 208 Harvard Street, Dorchester, Massachusetts.

ADDRESS OF WELCOME

PROFESSOR NORTON A. KENT

Mr. Chairman and Members of the New England Associations of Physics, Chemistry, and Biology Teachers.

Indeed I welcome you, and that right cordially—you who are my former pupils and my friends of the olden time, and also you whom I wish I knew at least as acquaintances if not as full-fledged friends. To the "dark, gray town" I welcome you, to the marts of men where the dense stream of life "flows through streets tumultuous, bearing along so many gallant hearts, so many wrecks of humanity."

"Where should the scholar live? In solitude, or in society? in the green stillness of the country, where he can hear the heart of Nature beat, or in the dark, gray town, where he can hear and feel the throbbing heart of man? I will make answer for him, and say, in the dark, gray town. Oh, they do greatly err who think that the stars are all the poetry which cities have; and therefore that the poet's only dwelling should be in sylvan solitudes, under the green roof of trees." So speaks the Baron in Longfellow's "Hyperion."

The lamps of learning burn in country and in city wherever there may be a faithful hand to tend them, but in the dark, gray town the light of true wisdom renders greatest service in illumining the dark corners of men's minds.

Ours is a great profession—yours and mine. We enjoy advantages which even pastor and physician do not possess, for we can minister, if we will, to the intellect, soul, and body of the youth who almost daily sit at our feet. Yours is a harder task than mine. Your classes are in general larger, your hours of teaching longer, and your responsibility greater, for the material with which you deal is more plastic. Often the die already is cast when the student enters college. How grateful I am continually for the moulding you have done.

I often view your labors with astonishment and admiration. I wonder what I should do if I had to solve the problem not only of instruction, but also of constant discipline. My hands would go up in despair. The cases of discipline which arise in my experience are infrequent.

Of course, *your* pupils never go to sleep in class—they are too vigorous and you are too alert. They do not generally get a chance to slumber long in mine.

Seriously, however, our responsibilities are always great and more so than ever at the present time. What, then, is our duty to our students in these anxious days?

Let us discuss this duty in terms of present conditions: First, the material at hand, namely the youth of America; second, the environment; and third, the resources at our disposal in solving this problem. We shall then be able to map a course of action.

First, American Youth: During the last few weeks there have appeared in our newspapers numerous "letters to the editor," dealing with the attude of high school and college students. I quote from one such, written by Helen Van Gorder of Newton Center, in the Boston *Herald* of November 23rd.

"Cynical, disillusioned, confused youth is always a sad spectacle—at this, the most critical moment of our history, it is a frightening one. . . . When our youth can feel no deep compassion for the victims of aggression, no belief in the moral issue at stake in this war between totalitarianism and democracy, no conviction that there are values worth dying to defend, then we may well ask, 'Who is to blame?' I think the answer is, 'The school, the church or the home—perhaps all three'."

My opinion is that the picture here painted is rather too dark. My admiration for our young people is unbounded. In them there are potentialities for good as great as ever there were one hundred years ago. Read, I pray, on pages 6 to 10 of the December *Reader's Digest*, an article by Honoré Morrow, entitled "Child Pioneer." Here are the opening paragraphs:

"Let me tell you the epic story of 13-year-old John Sager, as I gleaned it from the letters and diaries of Oregon pioneers.

"In the fall of 1844, John appeared at the gate of Dr. Whitman's medical mission, in what is now the State of Washington, carrying a starving five-months-old baby sister. He was staggering before an emaciated cow on whose back were perched a sister aged eight, with a broken leg, and a sister of five who helped support the leg. A sister of three and one of seven walked beside his 11-year-old brother, Francis.

"Unaccompanied, John Sager and his five sisters and a brother, all younger than himself, had made their way from Fort Hall, 500 miles to the east, over the Oregon Trail, then little more than a horse track.

"The trail was frequented by predatory Indians and was so difficult that the migration of 1844, which John's parents had joined, went to pieces. Some died en route; others turned southwest into California. But John came through."

The urge behind this trek was the boy's ambition to realize his father's dream to make a great farm in the valley of the Columbia and so help keep Oregon Territory for America. Our youngsters are capable of just as fine courage and devotion to an ideal, if they are led to see the vision of a cause worth struggling for. What a grand fight many of them make for a college education! I knew personally a student who was so poorly clad that his socks were in rags and his feet in contact with the ground through holes in his shoes. I know of girls who are going without their lunches because they have not money for three meals a day. The young people are magnificent.

Second, Youth's Environment: We are in a period of grave crisis. The situation challenges us all to the most heroic efforts of which we are capable. Let me commend to your earnest consideration an interesting, sensible, and inspiring article entitled "What About Unity?" written by the columnist Raymond Clapper and appearing in the November 18th issue of *Life*. I quote part of the closing paragraphs.

"During the last ten years we have had many moments of inner soul-searching. We have been unsure of ourselves. We have been unable to

fathom some of the paradoxes before our eyes. We have had an abundance
of food, but we also had starvation. We had factories, but they did little
work although the wants of the people went unsatisfied. We have seen
other nations turn away from our kind of life. We have seen men coming
into power in other nations who said our way of life was futile and destined
to extinction. It was, they said, flabby, incompetent, decadent, poorly
devised to serve. They would have none of it for themselves and soon
they began extinguishing it wherever they could lay hands on it. They
promise to drive it from the face of the earth."

What an environment for youth! And yet, working in this environment,
youth *must* resolve that our civilization shall not go down in defeat.

Third, What of the resources at our disposal in this youth problem? We
have just passed through a political campaign unrivaled in intensity.
(Please note that this simple talk of mine is not to be a partisan post-
campaign address!) However our political convictions may differ, I am
sure that the majority, if not all, of you, will agree that we have had ex-
emplified in the person of Wendell L. Willkie a devotion to a great cause,
a singleness of purpose, a self-effacing service, and a supreme and kindly
tolerance toward all groups of men. What happened in the ranks of youth?
During this campaign many of our youngsters under fine leadership caught
a vision. Never in all my life have I seen more devoted service than they
rendered. Here lies a pertinent suggestion for the solution of our problem.

As to our line of action: Invigorated and strengthened by this crusade,
you and I can now wage with renewed vigor a battle in which we have for
many years been engaged—a crusade the aim of which is to lift the youth
of our country to higher and ever higher levels, physical, intellectual, and
spiritual. Ours is a campaign of education—the cornerstone of the founda-
tion upon which we build is the spiritual life.

The great historian, H. G. Wells, in his *Outline of History* repeatedly
states that all education to be worthwile must be basically religious.

Now, I have never had a course in the theory of education. The light
of my student lamp—a kerosene burner—illumined the writings of Caesar,
Cicero, Ovid, Sallust, Virgil, and Homer, the plays of the Greek tragedians,
also the theorems of Euclid and the calculus of Leibnitz. So, possibly, I
should tread gingerly when I roam in the sacred halls of the influential
schools of education which have grown so great of recent years. Yet, as
you may be interested in an experience of mine, I shall venture a con-
fession.

For some decades I have handed to many of my students, as they left
me to enter the career of teaching, a sheet entitled "Practical Suggestions."
I'll not weary you with these in detail. Suffice it to state that my sheet
contained for instance such suggestions as:

Take pains with each and every student, attractive or not.
Remember you are dealing with human souls.
Never lose your temper, nor even speak quickly.

Acknowledge your shortcomings and errors frankly.

Attempt to inspire your students with the wonders and beauty of the world.

Keep your ideals high and remember that to develop character in your students is even more important than to aid them in acquiring knowledge, for the soul is more important than the intellect.

Now for years I had known Professor Edwin H. Hall of Harvard, had admired him greatly as a noble citizen, a fine physicist, and a great teacher. About two years ago I took my sheet to him and asked for his criticism. The verdict was, "Very good, Mr. Kent, but there are too many rules. Jesus Christ gave only two," referring, of course, to: "Thou shalt love the Lord thy God with all thy heart, and with all thy soul, and with all thy mind. This is the first and great commandment. And the second is like unto it. Thou shalt love thy neighbor as thyself."

Specifically, then, our plan of action, yours and mine, is to strive with all the strength that lies in us to lay before the youth in our halls of learning these two fundamental laws of the religious life—urging them, if Jews, to be good and high-minded Jews, faithful to the best in Judaism; if Catholics, good and intelligent Catholics, faithful to the best in Catholicism; and, if Protestants, good and consecrated and militant Protestants, faithful to the very best in Protestantism.

Let us base their education upon religion, which, to quote my good friend and colleague, Dr. Brightman, is "allegiance to the highest values— that is the values regarded as highest by the individual or group—together with a cooperative and reverent attitude toward the objective source of these values—that is, God Himself."

Let us order our own lives so as to aid rather than retard the young minds who are searching after truth.

Let us continually hold before our young the vision of a better America and a better world, a world in which mercy is coupled with justice, a world of love and not hatred.

Let us enlist our students as co-warriors—magnificent young people they really are—in this the greatest and most lofty of crusades—the Battle for Righteousness.

Business Meeting

The following were elected to active membership:

Eben T. Colby, Winthrop High School, Winthrop, Mass.

Paul A. Hilli, Northeastern University, Boston, Mass.

James P. Murphy, South High School, Worcester, Mass.

Henry S. Needham, East Boston High School, East Boston, Mass., was elected an associate member.

It was voted that the following memorandum concerning Mr. John C. Packard, charter member and first president of the Eastern Association of Physics Teachers be included in the records, and that copies be sent to Mrs. Packard and to the Superintendent of Schools in Brookline, Massachusetts.

Memorandum About John C. Packard

We have lost one of the charter members, or one might almost say *the* charter member, of the Eastern Association of Physics Teachers. For it was due to Packard's initiative and foresight that the group of physics teachers was called together in 1895, the first association of departmental teachers in this part of the country.

John Calvin Packard came from Cape Cod, having been born on September 10, 1859, at Bourne, Massachusetts. He attended the Sandwich High School and Wilbraham Academy and was graduated from Wesleyan University, Middletown, Connecticut, in 1886 with a Bachelor of Arts degree, summa cum laude. He did his first teaching in East Greenwich Academy, Rhode Island, from 1886 to 1890, after which he became teacher of science and submaster in the Brookline High School. In 1924 he was made Head of the Department of Science, and this position he held until his retirement in 1937. When the high school building was remodeled and enlarged in 1932, the science laboratories were named for him by vote of the school committee.

In 1937 Mr. Packard received an honorary degree of Master of Arts from Wesleyan University and the honorary degree of Doctor of Science from Tufts College. For more than twenty years he was a deacon in the Baptist Church of Brookline. He died at his home, 7 Dana Street, Brookline, Massachusetts, on July 9, 1940, in his eighty-first year. Packard devoted forty-seven years of his long life to teaching boys and girls in the Brookline High School and at the same time took an active part in the life of the community.

It is not easy to estimate adequately the character and attainments of this man because he did so many things superlatively well. He was a remarkable class-room teacher, always alert, up-to-the-minute, and keenly alive to the needs and interests of his pupils. He was a clever demonstrator, who believed in putting into his teaching the applications of physics in the home and in the factory. He used to like to break away from the conventional apparatus of the textbook and to bring into the laboratory commercial machines. In 1917 Ginn and Company published his *Everyday Physics, A Laboratory Manual.* This book illustrates his great capacity for getting things just right. In short, he was a perfectionist. But he had a great breadth of interest, especially in all the natural sciences. In a word, he was a cultivated gentleman with whom it was a delight and an inspiration to talk. As a friend of the younger teachers, he was especially inspiring because he was always kindly but frank. Many of us in this association will look back with grateful appreciation upon this stimulating example of a persistent student, an outstanding science teacher, and a real Christian gentleman.

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Report of the Apparatus Committee

Mr. Edward B. Cooper, of Brookline High School showed a photoelectric relay. This unit uses a type 923 phototube, a 25A7GT diode-pentode

and a sensitive relay which can handle 100 watts or more non-inductive load. It is most convenient to operate as it requires only one power source, 110 volts, either A.C. or D.C. The outfit is easily assembled from blueprints available from *Popular Science Magazine* for twenty-five cents, the cost of parts totalling $5.88. A kit for a very similar relay is available for $5.90 from Lafayette Radio, 100 Sixth Avenue, New York, and 110 Federal Street, Boston.

A large apparatus constructed mostly of Ford parts was shown by Mr. John L. Clark of Chapman Technical High School, New London, Connecticut. It was described as a man-sized model of a four cycle gasoline engine, most ingeniously designed and constructed by Mr. Frederick Sparrow, a graduate of our school, and an instructor in the Engine Mechanics Department.
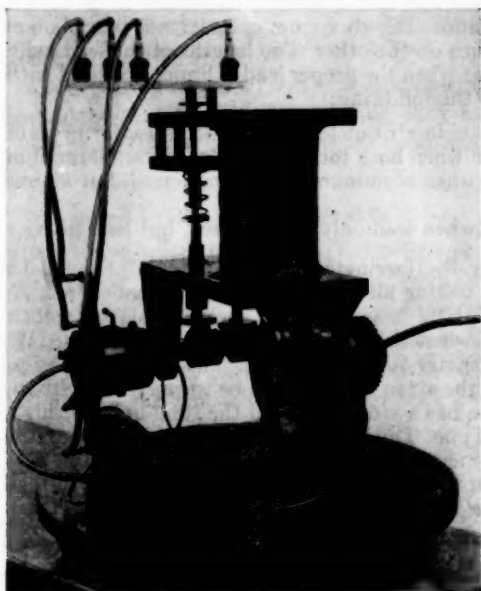
Demonstration Model of 4-Cycle Gas Engine

The model has the distinct advantage of being large enough for a class of forty students to observe in detail. With it the firing order of a four cylinder engine may be observed. The cam action and the operation of the valves are clearly visible as the piston moves within the cylinder. These valves may be easily and readily shifted to alter the opening and closing of the valves. Further, it is possible to advance or retard the spark, to bring out the effect on the action of the engine.

This teaching aid was entirely constructed from used Ford parts, an old iron pipe for a cylinder, and two castings, made at a negligibly small cost.

Mr. Arthur B. Stanley showed a photoelectric relay operated by a light source using either visible or ultraviolet rays. He also called attention to

a resistance box with switches instead of plugs, thus eliminating the possibility of dust getting into the openings. A third apparatus was a Wheatstone bridge of the conventional shape, (sometimes forgotten), and fourth, a simple generator model, of the three phase type, consisting of a permanent magnet rotating in a field of three coils, one or all of which may be removed.

Mr. W. Roscoe Fletcher of the North High School, Worcester, Mass. showed some apparatus for the demonstration of and interpretation of Archimedes Principle, emphasizing the fact that it holds true for all fluids, not merely for liquids. First was a density flotation series, mercury, monel metal, carbon tetrachloride, water, lignum vitae, and air.

This was followed by a specially constructed water baroscope. Three large lead cylinders and one made of aluminum were used. These were all of the same diameter, but of different lengths. A trip balance and stand were used and the cylinders suspended from the hooks under the pan of the balance. The aluminum cylinder was placed on one side and the lead ones in turn on the other. The lengths of the lead cylinders were constructed so that when the proper lead cylinder was used with the aluminum one it showed the following:

1) Same mass in air but lead apparently heavier in water.
2) Balanced when both totally submerged, but aluminum heavier in air.
3) Balance when aluminum only is immersed, but aluminum heavier in air.
4) Balance when lead only is immersed, but lead heavier in air.

Mr. Charles B. Harrington of Newton High School demonstrated an apparatus for testing all the gas laws at the same time. A capillary tube 50 centimeters long has a pellet of mercury blocking off a column of air 29.3 cm. long when the observed temperature is 20 C. When warmed it rises one millimeter for each degree. This tube is immersed in a water-jacket so that the air in the tube can be warmed. A right angle bend at the top of the tube has a stop-cock, and the tube beyond this is attached to a Boyle's Law Tube. Thus both temperature and pressure may be changed at the same time or separately.

Mr. Woodard of Exeter Academy demonstrated a similar apparatus, having a larger tube containing 30 cubic centimeters of gas instead of the capillary tube.

SEISMOLOGY AND ITS APPLICATIONS

DANIEL LINEHAN, S.J.

The word "Seismology" means, from the two Greek roots forming it, the study of shakes, or the study of vibrations. Hence, we would expect the seismologist to be ready to engage in the research of any type of vibrations, not only of the earth, but of airplanes, moving trains, architecture, water, air, etc. However, when the study of earthquake phenomena was put on a systematic basis, and it was found that vibrations were the important part of the study, the name "Seismology" was applied to this field of science. While at first the science was concerned only with earthquakes, today we find its scope ever widening and the definition approaching its fullest meaning.

EARTHQUAKE HISTORY

Earthquakes have been observed and feared since man first came on this earth. Geological history demonstrates too, that they were extant back to the earliest ages of our rocks. However, their true factors and qualifications were hidden in a mass of folklore until the past half century. Even though dependable histories of earthquake phenomena were written as early as 1000 B.C. and numerous other non-instrumental studies made, still science did not bring out the truth until this later date. Names like Mitchell, Vincenzio, von Huff, Lyall, Noggerath, Mallet, de Rossi and very many others are names familiar to the student of earthquakes and each played his or her important part in seismology. The real advance, however, came with John Milne, an Englishman, and it seemed to come overnight. He covered almost every field of seismology and developed instruments and theories that have won for him the title: "The Father of Modern Seismology."

The inertia resulting from Milne's great scientific push has carried seismology far, and today we are not so concerned with making new discoveries, as much as we are striving to develop those made by him and his confreres in time.

EARTHQUAKE MECHANISM

Earthquakes have frequently been associated with volcanic activity in the minds of most people, and this is in part true. Volcanic regions do suffer earthquakes, but they are usually of local importance and play no part in a world wide study. The type interesting to us is known as a "tectonic" quake, and which plays a great part in the architecture of the earth; it is more deep seated than the volcanic quake, and may be felt at greater distances, instrumentally, at least, if not personally.

Tectonic quakes, in brief, are nothing more than the fracture of some great rock stratum or strata, due to an increasing amount of differential strain or pressure. This amount may increase to the extent where the elastic limit of the rock is reached, fracture occurs, and the potential energy is released in its kinetic form ready to do work. The cause of the differential strain or pressure is another question to be solved, it may be due to isostatic adjustment in the earth's crust, or to contraction of the crust by shrinkage, etc. The transmission of the energy released is accomplished as in so many other phenomena in nature,—by wave motion. When we consider the enormous amount of energy required to fracture some of the rock strata and the amount of displacement that so often ensues, we are not surprised at the amount of kinetic energy found in the waves resulting, waves that may accomplish so much destruction and be recorded at all distant corners of the earth.

WAVE TYPES

There are three main types of waves generated at the source of the earthquake. A compressional wave, a shear or transverse wave, and one

similar to the gravity wave we recognize on water. The first travels through the body of the earth at a velocity varying from about 4 miles per second to near 8 miles per second; the second wave follows the same path, but its velocity is only 3 to 6 miles per second. The velocities as you will note are not constant but vary according to the depth the wave travels in the earth as there the elastic constants differ. Each of these types suffers reflections from the earths mantle, from it's core, and from various other reflecting surfaces; the transverse type, of course, will break up into polarized and non-polarized phases. Following these direct waves and their numerous reflections, come the third type or surface waves. These travel along the surface of the earth and at a fairly constant velocity of about 2 miles per second. The number of waves at the focus or source of the quake was simple, but the resulting pattern at a distance is quite complicated and may be realized by the examination of a seismic record. The actual ground movement at the quake source may have taken but a few seconds, but at a recording station some miles away the various reflections and refractions may record for hours.

SEISMOMETERS

The problem of developing an instrument for measuring or even detecting a seismic wave is an interesting one. When one attempts to measure the velocity of any object, and that is the object of a seismologist in measuring seismic waves, the instrument he employs must be independent of the object being measured. For example,—if I wish to measure the velocity of a stream of water, I must fix my instrument to the bank of the stream and then measure the velocity with respect to the bank of the stream; if it is wind, I must measure the velocity with respect to the ground, or house, or to whatever I have fixed the measuring instrument. In measuring the velocity of earthwaves there is difficulty in finding a base on which to fix the instrument. We cannot imagine just placing it on the earth as that is the object we are trying to measure. In as much as the earth surface all over is moving in a quake we shall find difficulty finding a fixed instrument that will measure this motion.

We may have noticed, perhaps, the skilled magician who will pull a table cloth from under a set of dishes without even disturbing these dishes. They remained in their original position and as we know, due to their inertia. One of the best examples of an inertia instrument is the simple pendulum. If such an instrument is suspended properly, its support may be shaken back and forth and the pendulum bob will move but very little. If we fix the support to the earth, we can readily see that any motion of the earth will have but small effect resulting in motion of the bob, and we shall be able to detect a relative motion between the bob and the support or the earth. The fundamental principle of almost every seismograph is the pendulum, the only exception employed to date is an instrument devised to measure the stress and strain set up in the earth between two points.

Pendula have been devised under many forms to detect earth motion; some are of a long period, some short, some horizontal and some vertical; some employ gravity as their restoring force, others use the torsion effect or diaphragm force, etc. The methods of transducing this detection of motion are also many,—it might be a stylus on smoked paper, pen and ink on blank paper, or a light spot on photographic film.

Some instruments are developed for recording only short period motions of the earth, and others long period motion. The period of the waves may vary according to the distance from the station to the quake focus; the depth of focus of the quake; or even according to the station locality. The station designer must choose the type he desires to study before installing his instruments, although in practice the better observatories will install all periods possible. The limit is usually determined by their budget.

STATION OPERATION

Station operation consists in reading each days' records and locating the quakes found thereon. The distance of a quake from a station is easily determined by examining what time the compressional waves arrive before the transverse waves. Knowing their relative speeds, observing their arrival time differences and realizing that both waves started at the same time, the computer may easily figure how far they both travelled. In practice as many of the secondary waves as possible are also read to check. Direction of the quake from a station may be determined by having several instruments aligned according to the compass points; two for the horizontal and one for the vertical component will suffice. With reports from several stations available, the respective distance circles to each station are drawn on a map and where these intersect is the location of the quake, or the quake epicenter.

There are several Central Stations to which all data are sent immediately following interpretation, and at these stations the data are compiled and the epicenters located. In the United States there are two main such stations, one the Office of the United States Coast and Geodetic Survey in Washington, and the other at St. Louis University, the Central Station for the Jesuit Seismological Association. Local areas conduct similar tactics, but on a smaller scale and only for local seismic disturbances. In the Northeastern United States and Eastern Canada, Weston College at Weston, Massachusetts, is the Central Station for all observatories and stations in this section. The member stations, comprise Harvard University, Massachusetts Institute of Technology, University of Vermont, Fordham University, University of Pittsburg, Williams College, one or two private stations, and several stations operated by the Canadian Government in Eastern Canada.

For some years now, an enormous amount of material has been garnered from records. The major earthquake regions of the earth have been plotted; the possibility of quakes in this or that region determined; tables on velocities of seismic waves compiled; varying depths of earthquake

foci listed; everything that is possible of interpretation from the records has been utilized. The advance of this science in a few score of years and with comparatively so few men engaged, has been remarkable.

UTILITY OF SEISMOLOGY

The question is frequently asked: "What real value has the science of seismology accomplished for the world?" Indeed, it seems to many that, the final purpose of the seismologist is to announce to the radio or newspapers that an earthquake happened some twelve hours ago, somewhere. We are asked if anything has been done to stop earthquakes, or lacking that, if anything has been acomplished in the way of predicting them. The answer of the seismologist is simply, "No!"

Occasionally we hear of someone predicting earthquakes, but the type of predictions offered have had little scientific or practical value. It would be very similar to the weatherman who predicts that, "it will rain to-morrow somewhere on this earth," or even designating a locality as the "western hemisphere." When we consider that earthquakes occur on the average of several every hour, and major destructive types every six days, predictions are of little value unless they can designate the place and time exactly.

Comparisons have been made with the frequency of earthquakes and the occurrence of sun spots, earth tides, seasons of the year, weather, etc. We hear that earth tides may act as the "trigger effect" that will "set off" an earthquake. But first, as we may well realize, the gun must be loaded, that is, there must be sufficient stress and strain stored in the earth's rocks so that it is nigh the breaking point, and we have a real difficulty in determining that, especially if the rocks we are trying to study are several hundreds of miles deep in the earth. Predictions of earthquakes may come in the future, as science has performed wonderful things in the past, but at present seismologists are worrying about other and more hopeful outcomes.

Early in their studies, seismologists noted that loss of life was not due to the earthquake alone, and that there was little danger of the crust of the earth opening wide and swallowing peoples whole. The danger lay in man's own architecture collapsing under the earth's vibration and burying the builder. The effort has been made to build houses that would stand the strain of such movement, and to lessen the danger of walls, roofs, cornices, etc., from falling. In the construction of the "Shaking Table," seismologists have brought the earthquake into the laboratory and have simulated earthquake movement on a smaller scale and on models of building construction. Their construction is changed to minimize their shaking apart and then these principles have been applied in practice with very satisfactory results. Many cities in regions of seismic activity have incorporated a building code based upon the findings of seismologists, and buildings constructed according to this code have withstood the ravages of earth vibrations very well.

GEOLOGICAL RESEARCH

Our knowledge of the earth's interior has been greatly advanced by seismic research. In the physics or the chemistry laboratory, as we know, analyses are frequently made with the spectroscope. Using this method the technician observes the various waves of light that a burning gas emits, and makes his analysis from the various wave lengths of the light. Each element has its own light wave pattern. The method of the seismologist is quite analogous. By studying the waves from distant quakes, determining their velocities, counting their reflections or refractions, observing the plane of polarization, he may later construct the media through which these waves have passed and thus present a picture of the earth's interior. He can number the various layers that make up the earth, give the dimensions of each layer, and state many of the factors of each layer. The deepest that man has yet gone into the crust of the earth is something in the order not exceeding 3 miles, but the seismologist will take you, and with great accuracy, to the earths center, a distance of almost 4,000 miles.

If we employ this method on a reduced scale, and instead of waiting for an earthquake as the source of our waves, use a large dynamite blast, detailed studies may be made of certain sections of the land. Where large quarrying operations are employed, as in New England, seismologists are constantly studying the effects of quarry blasts, and have drawn maps demonstrating geologic structure down to depths of some tens of miles.

SEISMOLOGY IN COMMERCE

The method mentioned above may be reduced still further. Using portable equipment that may be transmitted easily from place to place, and using small charges of dynamite, a pound or so, geologic structure may be determined very accurately from depths ranging from two or three feet down to several thousands of feet. This is indeed one of the most important by-products of earthquake research as it affects our daily lives, as it has been incorporated in the Petroleum Industry to locate new sources of oil. For the past few years every large Oil Company has had many "Seismic Crews" in the field trying to uncover geologic conditions that will yield greater oil supply. The method is indirect, of course, as it does not mark the presence or lack of oil, but it will point out very accurately such geologic structures as domes, faults, rises, etc., where oil will accumulate in reservoirs. It has done away with the necessity of "wildcat" methods of drilling, and the saving of needles drilling expense is reflected in the purchasing price.

Apart from oil-prospecting, seismology has been of the greatest aid to the engineer. The location of bed rock under a gravel cover is important to the engineer of dams; location of bed rock for tunnel construction, that the engineer may avoid great valleys in the rock or faulted areas; the hydraulic engineer may want to know the position of an underground water channel, the center of a drainage area, etc. All such problems may

be worked out by seismic methods even though hundreds or thousands of feet of gravel, sands and other such deposits may cover the bed rock.

In other fields such as bridge building the seismograph has played an important part. It denotes the amount of sway and change of period a bridge suffers during its period of construction. Skyscrapers must maintain a definite period to withstand certain wind velocities, and this is also checked by the seismograph. The vibrations of trucks and commerce of various types of roadwork have been studied by seismic methods. There are countless other applications. The surprising part of the advance of seismology into other fields however, is not the number of fields it has entered with success, but that it has been accomplished in so short a time. May we not hope for even greater aids from this science in the years to come!

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1676, 8, 9. *Julius Freilich, Brooklyn, N. Y.*

1670, 1, 5, 6, 8, 9. *C. W. Trigg, Los Angeles.*

1678. *John P. Hoyt, Cornwall, N. Y.*

1674. *Jefferson Hoagland, Farleys, N. Y.*

1676, 7, 9. *M. Kirk, West Chester, Pa.*

Problem 1661.

In the 1940 October issue page 675 the statement is made by the Editor

that the system of equations has no unique solution. **The work given below will be of interest to those who have been puzzling over this problem.**

1661. *Proposed by John Z. Biggerstaff, Portland, Ore.*

Solve the system:

$$\frac{x-yz}{\sqrt{(1-y^2)(1-z^2)}}=a$$

$$\frac{y-xz}{\sqrt{(1-x^2)(1-z^2)}}=b$$

$$\frac{z-xy}{\sqrt{(1-x^2)(1-y^2)}}=c.$$

Solution offered by the proposer.

$$\frac{x-yz}{\sqrt{(1-y^2)(1-z^2)}}=a \qquad (1)$$

$$\frac{y-zx}{\sqrt{(1-z^2)(1-x^2)}}=b \qquad (2)$$

$$\frac{z-xy}{\sqrt{(1-x^2)(1-y^2)}}=c. \qquad (3)$$

Squaring (1) and subtracting 1 from both sides

$$\frac{x^2-2xyz-1+y^2+z^2}{(1-y^2)(1-z^2)}=a^2-1. \qquad (4)$$

Similarly from (3),

$$\frac{z^2-2xyz-1+x^2+y^2}{(1-x^2)(1-y^2)}=c^2-1. \qquad (5)$$

Multiplying (1) by (3)

$$\frac{(x-yz)(z-xy)}{(1-y^2)\sqrt{(1-x^2)(1-z^2)}}=ac. \qquad (6)$$

Adding (2) to (6)

$$\frac{y(-z^2-x^2+2xyz+1-y^2)}{(1-y^2)\sqrt{(1-x^2)(1-z^2)}}=ac+b. \qquad (7)$$

Forming the product of (5) and (5);

$$\frac{(x^2-2xyz-1+y^2+z^2)^2}{(1-x^2)(1-y^2)^2(1-z^2)}=(a^2-1)(c^2-1). \qquad (8)$$

Squaring (7) and dividing the result by (8)

$$y^2=\frac{(ac+b)^2}{(a^2-1)(c^2-1)}.$$

The values of x^2 and y^2 may be found from symmetry.

Problem 1595.

Editors Note: The solution to this problem was given by Analytic Geometry. Correspondence has shown a desire to see a solution by Plane Geometry—and one is now offered.

Proposed by Richard Doner, Syracuse, New York

Through a given point draw two transversals which shall intercept given lengths on two given lines.

Solution by John P. Hoyt, Cornwall, New York

For the general case where the two given lines are intersecting, let OA and OB be the given lines, let l and m be the two given lengths, and let P be the given point. Assume the problem done and let DE and CF be the required lines cutting off segments as indicated in figure. Through P, draw PH parallel to OB and PI parallel to OA, and letter the segments as indicated on figure. Hence from similar triangles.

$$y/b = EP/DP \quad \text{and} \quad z/a = DP/EP.$$
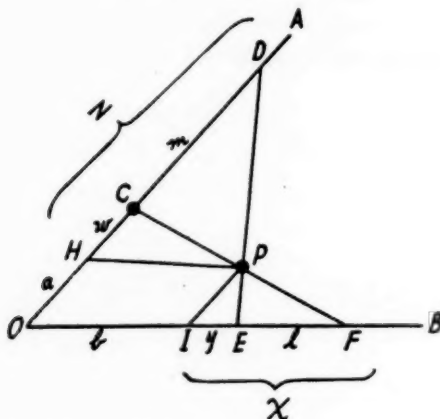
Multiplying $yz/ab = 1$ from which $yz = ab$ (1)

In like manner $xw = ab$ (2)

Also $x - y = l$.   (3)

And $z - w = m$.   (4)

Solving equations (1), (2), (3), and (4) simultaneously,

$$w = -\frac{ml \pm \sqrt{m^2 l^2 + 4lamb}}{2l}$$

$$w = -\frac{m}{2} + \frac{\sqrt{m^2 + \dfrac{4amb}{l}}}{2}.$$

$\sqrt{m^2 + 4amb/l}$ is the hypotenuse of a right triangle one of whose legs is m and the other is twice the mean proportional between a and mb/l. Also mb/l is the fourth proportional to l, m, and b. This hypotenuse is bisected and $m/2$ subtracted from it. The resulting line is w which of course can be laid off from the known point H locating point C after which CP determines one of the transversals and D is then obtained by laying off m from C and hence DP is determined.

1681. *Proposed by Charles P. Louthan, Columbus, Ohio.*

A square hole 4″ by 4″ is punched vertically through a horizontal cylinder of radius 5″, two sides of the hole being parallel to and 2″ from the axis of the cylinder, F and the area and volume cut out.

First Solution by Arthur Danzl, Collegeville, Minn.

Taking equation of cylinder as $y^2 + z^2 = 25$ we have as Area,

$$A = 8 \int_0^2 \int_0^2 \left[1 + \left(\frac{\partial z}{\partial x} \right)^2 + \left(\frac{\partial z}{\partial y} \right)^2 \right]^{1/2} dx dy = 80 \text{ arc sin } \tfrac{2}{5} = 33.04 \text{ (sq. in.)}$$

The Volume, $\quad V = 8 \int_0^2 \int_0^2 \int_0^{\sqrt{25-y^2}} dz \cdot dy dx$

$$= 16\sqrt{21} + 200 \text{ arc sin } \tfrac{2}{5} = 155.93 + \text{(cubic inches)}.$$
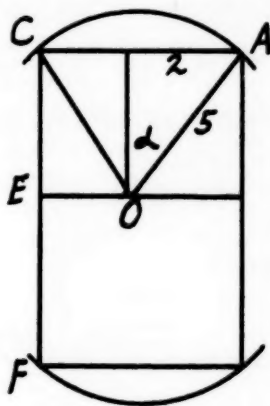
Second Solution (Author's name not given)

In the figure O is on axis of cylinder, and the circular sector OAC is in plane perpendicular to axis. Call the area of this plane S. With AF as base of solid, the altitude is 4. Let s =length of arc AC; A =area cut out; V =Volume cut out.

$$s = \frac{2d}{360°} \cdot 2\pi r = \frac{\pi r d}{90°}$$

$$d = \text{arc sin } \tfrac{2}{5} = 23.58° = .4116 \text{ (radians)}$$

$$\therefore \quad s = 2 \times 5 \times .4116 = 4.116 \text{ (in.)}$$

A (both surfaces) $= 2 \times 4 \times 4.116 = 32.93$ (sq. in.)

$$V = \text{Area of plane } s \times 4 = 2(\text{area of sector } OAC + 2 \text{ area of } \triangle ECO) \times 4$$

$$= 2 \left(\frac{2d}{360°} \cdot \pi r^2 + 2 \frac{EO \cdot EC}{2} \right) \times 4$$

$$EC = \sqrt{OC^2 - EO^2} = \sqrt{25-4} = \sqrt{21} = 4.583 \text{ in.}$$

$$\therefore \quad V = 8(10.29 + 9.17)$$

$$= 155.7 \text{ cu. in.}$$

Note: Four place accuracy has been used throughout the solution of the problem.

Solutions were also offered by Joseph M. Synnerdahl, Chicago, Illinois; Paul C. Overstreet, Wilmore, Kentucky, Julius Freilich, Brooklyn, Chas. W. Trigg, Los Angeles, M. Kirk, West Chester, Pa.

1682. *Proposed by E. H. Cooper, South Bend, Ind.*

Find the sides of an inscribed quadrilateral, such that its area will be $\sqrt{(x+1)!}$, x being the length of the longest side.
No solution has been received.

1683. *Proposed by C. W. Trigg, Los Angeles, Calif.*

$ae^z + be^{-z}$ can be written in the form $r(e^{z+c} + e^{-z-c})$, where r and c are fixed numbers. Find r and c

Finst Solution by Aaron Buchman, Buffalo, N. Y.

Expanding each of the given expressions into a series, we have

$$ae^z + be^{-z} = (a+b) + (a-b)x + (a+b)\frac{x^2}{2!} + (a-b)\frac{x^3}{3!} + \cdots$$

$$r(e^{z+c} + e^{-z-c}) = (re^c + re^{-c}) + (re^c - re^{-c})x + (re^c + re^{-c})\frac{x^2}{2!} + \cdots.$$

Equating like powers of x, we have

$$re^c + re^{-c} = a + b$$
$$re^c - re^{-c} = a - b.$$

Solving for a and b, we have

$$a = re^c \tag{1}$$
$$b = re^{-c}. \tag{2}$$

Multiplying (1) and (2) and taking the square root

$$r = \sqrt{ab}. \tag{3}$$

Substituting (3) in (1) and solving for c

$$c = \tfrac{1}{2}(\log a - \log b). \tag{4}$$

Second Solution by the Proposer

$$ae^z + be^{-z} = re^{z+c} + re^{-z-c}.$$

Put
$$ae^z = re^z e^c, \quad \text{whence} \quad a = re^c. \tag{1}$$
$$be^{-z} = re^{-z} e^{-c}, \quad \text{whence} \quad b = re^{-c}. \tag{2}$$

Multiplying (1) by (2)

$$r^2 e^0 = ab, \quad \text{so} \quad r = \sqrt{ab}.$$

Dividing (1) by (2),

$$e^{2c} = a/b, \quad \text{so} \quad c = \tfrac{1}{2} \log_e (a/b).$$

Solutions were also offered by Paul C. Overstreet, Wilmore, Kentucky; A. E. Gault, Peoria, Illinois; C. W. Trigg, Los Angeles, California; Julius Freilich, Brooklyn, New York; George Ross, Brooklyn, New York; M. Kirk, West Chester, Pa.

1684. *No solution received.*

1685. *Proposed by H. D. Groosman, New York City.*

Find the principal value of $\sqrt[\sqrt{-1}]{-1}$

Solution by Aaron Buchman, Buffalo, N. Y.

The following fundamental relation can be found in any textbook on calculus.

$e^{iz} = \cos z + i \sin z$, where $i = \sqrt{-1}$ and z is any real or complex number.

Let $\quad z = \pi$

$e^{i\pi} = \cos \pi + i \sin \pi = -1.$

Taking the i-th root of each side,

$e^{\pi} = \sqrt[\sqrt{i}]{-1}.$

Solutions were also offered by A. E. Gault, Peoria, Illinois; H. D. Groosman, New York City; Paul C. Overstreet, Wilmore, Kentucky; Julius Freilich, Brooklyn, New York; Roy Wild, New Boston, Missouri; Arthur Danzl, Collegeville, Minnesota; George Ross, Brooklyn, New York; Dorothy Clappert, Portales, New Mexico.

1686. *Proposed by Arthur Brooks, Ledger, N. Y.*

If a and ba are positive and $a + b = 1$, show that

$$(a + 1/a)^2 + (b + 1/b)^2 \geq 25/2.$$

Solution by David X. Gordon, Brooklyn, New York

Let $\qquad a = \tfrac{1}{2} + x \qquad\qquad\qquad a^2 + 2 + 1/a^2 + b^2 + 2 + 1/b^2$

$\qquad\qquad b = \tfrac{1}{2} - x \qquad\qquad\qquad = a^2 + b^2 + \dfrac{a^2 + b^2}{a^2 b^2} + 4.$

Then $\qquad a^2 + b^2 = \tfrac{1}{2} + 2x^2\tfrac{1}{2} \qquad\qquad \geq \tfrac{1}{2} + \dfrac{\tfrac{1}{2}}{\tfrac{1}{16}} + 4$

$\qquad\qquad ab = \tfrac{1}{4} - x^2\tfrac{1}{4} \qquad\qquad\qquad \geq 12\tfrac{1}{2}.$

Solutions were also offered by Julius Freilich, Brooklyn, New York; Paul Overstreet, Wilmore, Kentucky; Marcellus Dreiling, Collegeville, Indiana; George Ross, Brooklyn, New York; M. Kirk, West Chester, Pa.; Dorothy Clappert, Portales, New Mexico.

PROBLEMS FOR SOLUTION

1699. *Proposed by John P. Hoyt, Cornwall, New York*

In any triangle ABC with centroid G, FH is any line through G meeting AB at F and AC and H. Prove $BF/FA + CH/HA = 1$.

1700. *Proposed by Frank Hall, Sheldrake, New York*

Construct the triangle ABC, if sides a and c and median m_b are given.

1701. *Proposed by D. F. Wallace, Saint Paul, Minnesota*

In quadrilateral $ABCD$, M and N are mid-points of diagonal BD and AC respectively. MN meets AB at R and BC at S. The diagonals of quadrilaterals $MSCD$ and $RNCD$ meet at E and F respectively. Prove that AF, BE, CD and lines drawn from R and S parallel respectively to AC and BD are concurrent.

1702. *Proposed by Paul C. Overstreet, Wilmore, Kentucky*

Show that for every perfect cube, n^3, there exist a series of n consecutive odd integers whose sum is n^3.

1703. *Proposed by L. C. Fender, Leon, Iowa*

"Find the smallest number which is divisible by 17, and which when divided by the number 2 to 16 inclusive leaves a remainder of 1."

1704. *Proposed by Vincient J. Frost, Aurora, New York*
Solve for x: $(x+a)^4+(x+b)^4=17(a-b)^4$.

STUDENT HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

1680. *Frank Chlosta, Cheboygan, Mich.*

SCIENCE QUESTIONS

February, 1941
Conducted by Franklin T. Jones,
10109 Wilbur Avenue, S.E., Cleveland, Ohio

911. *Where does Science Teaching begin? And who does the first science teaching?*

What is your answer? (Here is one answer.)

Information about scientific matters begins long before a child starts to school. Toys, wagons, bicycles, falling down, working the muscles—all are part of an education which is fundamentally scientific.

Unless it is recently, this early scientific background with which a child enters school is neglected in following out the course of study. Reading, writing, figuring follow along and we are tempted to urge elementary minds into complicated channels. School, if a so-called "progressive school," becomes play. In many other cases there is an attempt to make the little child a "thinker." In both cases, perhaps, the teacher and the course-of-study-maker lose track of the fact that learning is very much like walking in the fact that walking is a continuous process and the laws of nature compel the walker to "keep his feet on the ground" and travel "a step at a time."

Maybe our science teaching has not changed over the years in a very important particular: namely—we try to teach first the last thing we learned instead of figuring out what should be taught first and leading up to the very interesting things which we learned last.

As I understand it, the *Elementary Science* program is a careful attempt to remedy our former mistakes and failings. With this interpretation it should receive every encouragement.

In the January number of SCHOOL SCIENCE AND MATHEMATICS this Department began to publish some questions on *Elementary Science*. As long as they seem to meet a valuable response, they will be continued. F.T.J.

Contributors to Science Questions are accepted, as their contributions are accepted, into the GQRA (Guild of Question Raisers and Answerers).
Classes and teachers are invited to join with others (361 since 1934) in this co-operative interesting venture in science.

ELEMENTARY SCIENCE TOPICS

907. *Propose a list of not more than* ten *topics that elementary science teachers find interesting to their classes.*

(What are your ten pet subjects?)

Answer by Dr. David W. Russell (Elected to the GQRA, No. 357), National College of Education, and Departmental Editor of SCHOOL SCIENCE AND MATHEMATICS. *Editor, Educational Department, The Bobbs-Merrill Company, Indianapolis, Ind.*

"My *ten* pet topics cover a lot of territory. Here they are—

1. Questions that deal with stars and other astronomical data other than the usual material about distance and speed.

Astronomy is taught in most of the elementary science programs but, unfortunately, many teachers know little about the elementary facts.

2. Any kind of arithmetic questions that make arithmetic "come to life." Questions that relate common number work to a youngster's everyday experiences. Sometimes items can be related to the sports such as basketball and baseball.

3. Scientific questions concerning habits of bugs and animals are interesting to children and their teachers. A cat, for instance, laps its milk by curling its tongue under instead of over. (You probably heard some of the scientific "errors" in the panel this morning—Meeting of CAS&MT at Cleveland, Nov. 30th, 1940.)

4. Teachers and youngsters like some of the tricks like the sweet potato growth, the grape fruit seeds, etc. Remember how the "coal and iodine" rage swept the country. Few people knew how this "flower" developed.

5. Chemical plants are becoming the rage in some elementary science classrooms. Mathematical or scientific help along this line would be welcome, I think.

6. Questions on tree-planting, or yearlings, would be helpful. Often the Sequoia "Big Tree" and the Redwood are considered the same when, as a matter of fact, they differ greatly even in development.

7. Radio and television questions can be handed to elementary pupils. Many people do not realize that the radio voice is not the original voice. Some of this material can be reduced to spheres of elementary school interest.

8. Health questions and health education are gaining prominence at the present time. There will be over 200,000,000 colds this winter. Why?

9. "Safety and Science" is an interesting topic and might even offer a suggestion for a good article.

10. A "This Month in Science" would be very helpful to teachers. It might be a sort of a survey of things that are happening condensed into one fact after another.

I would like to know what others have to say about their 'Ten Pet Subjects'." DAVID W. RUSSELL

INTEREST RAISERS IN ELEMENTARY SCIENCE

(Interest raisers, Nos. 1 to 5, were published in January, 1941. They were contributed by boys and girls at Doan School, Cleveland. Answers will be found below.)

Interest raisers, Nos. 6 to 10, are sent in by boys and girls from Almira School, Cleveland, Ohio, Miss Dorothy Bliesch, Teacher. This class is elected to the GQRA. Their number is 358.

6. When a balloon sails up in the air, why doesn't it go up forever?
7. Could you take the Yankee Clipper to the moon?
8. How hot will boiling water get if we turn on more gas?
9. Can a cloud "burst"?

10. Name one animal that would drown in water when full grown but would drown in air when young.

ANSWERS TO INTEREST RAISERS, NOS. 1 TO 5

Contributed by Miss Edna Byrne and Pupils, (Elected to the GQRA, No. 361) Doan School, Cleveland, Ohio.

1. Do all clouds give rain?

No; whether or not a cloud gives rain depends upon the temperature. When it becomes cold enough, it gives snow, hail, or sleet. When the cloud is sufficiently warm, the water vapor in it does not condense.

2. Why isn't the earth overrun with plants and animals?

The earth is not overrun with plants and animals because each year many are used for food by other living things. Consequently, many young ones never grow up. When plants and animals die, they decay and become part of the soil.

3. Why don't all birds migrate?

Scientists do not agree on why birds migrate. Some birds can find food and shelter in the cold winter months. Therefore, they do not need to migrate.

4. Why is the beaver called our first conservationist?

The beaver is called our first conservationist because it builds dams. This slows up running water and often prevents floods. The beaver did this long before man thought conservation was necessary.

5. If a comet's tail touches the earth, could we gather any pieces from it?

No, because 2000 cubic miles of the tail of a large comet would not have as much material as one cubic inch of air on our earth.

ELEMENTARY SCIENCE TOPICS

907. (*Repeated from January*)

Propose a list of not more than *ten* topics that elementary science teachers find interesting.

What are your *ten* pet topics?

(*See topics by Dr. David W. Russell, above.*)

A HOMEWORK EXERCISE IN CHEMISTRY

912. *Contributed by Dr. J. Russell Bright, Instructor of Chemistry, Wayne University, Detroit, Mich. (Elected to the GQRA, No. 360.)*

"Here is a type of Homework Exercise with which my class has lots of fun. I would like to submit it for the department which you conduct in SCHOOL SCIENCE AND MATHEMATICS."

Consider all the following statements for they are necessary to a correct solution of the problem. Four volatile compounds (A, B, C, and D) are all oxides of non-metals.

(1) Percentage of oxygen in A minus percentage of oxygen in B equals 10%.

(2) Molecular weight o fA is 25% greater than that of B.

(3) C has the same molecular weight as D.

(4) D supports combustion.

(5) Molecular weight of A is 80.

(6) B is 50% oxygen but contains the same elements as A.

(7) A contains sulfur.

(8) C is always present in the air.

(9) D contains element of atomic number 7.

(10) C is a normal product of combustion of fuel.

  I. Write the simple formula of each of the compounds mentioned above.

 II. Illustrate or give example of each of the ten statements.

III. Write a structural formula for the acid produced by hydrolysis of each of the above.

 IV. Make a table showing physical properties of each substance.

ANSWER TO A BRAINTEASER

900. *From "The Double Bond," Niagara Falls, New York.*

"The ocean liner SS *Montauk* was anchored in New York harbor. A spectator on the dock noticed a rope ladder hanging from the topsides. Furthermore, he noticed that the bottom four rungs of the ladder were just submerged, that each rung was 2 inches wide and that the rungs were 11 inches apart. If the tide was rising at the rate of 10 inches an hour, how many rungs would be submerged at the end of two hours?"

Answer. The four bottom rungs. The vessel will float just so deep no matter how high the tide rises. The ladder will rise with the boat.

DO YOU KNOW THE ANSWERS

(Refer to *Science News Letter*, January 4, 1941)

121. What are the *sulfa drugs?*

122. What deadly disease is being conquered by these drugs?

123. What is the "freezing level"?

124. How and where do fuelless hot water systems operate?

125. What kind of a beam is supposed to guide bats and save them from collisions with walls of caves in which they live?

ANSWERS TO "SOME QUESTIONS
ABOUT WAR CHEMISTRY"

111. Phenol is now synthesized by the Raschig process from air and two common chemicals, benzene and hydrochloric acid, in a new plant at North Tonawanda, N. Y. Cost, $2,000,000; capacity, 15,000,000 pounds of phenol per year; to operate requires only six men and a supervisor.

112. Losses of iodine from "iodized salt" can be minimized through the use of finely ground calcium stearate. Nearly insoluble, the calcium stearate covers the salt grains with a nearly impermeable coating which prevents escape of iodine. A treated sample of salt lost 1% of its iodine in four months while an untreated sample lost 15%.

113. A peacetime use for "tear-gas" chloro-pictin (CCl_3NO_2) might be as a rodent destroyer; but—you better use something else. It is toxic.

114. Sodium amytal delays onset of shock which is a grave danger in battle wounds.

115. The morale vitamin is a Vitamin B complex.

Readers and classes are invited to propose short sets of questions for

publication under the "Some-Questions-about—" section. Membership in the GQRA will be awarded for suitable lists.

NEW MEMBERS—FEBRUARY, 1941

357. *Dr. David W. Russell, National College of Education, Evanston, Ill.*
358. *Elementary Science Class, Almira School, Cleveland, Ohio, Miss Dorothy Bliesch, Teacher.*
359. *Miss Mary Melrose, Supervisor of Elementary Science, Cleveland, Ohio.*
360. *Dr. J. Russell Bright, Instructor of Chemistry, Wayne University, Detroit, Mich.*
361. *Miss Edna Byrne and Pupils, Doan School, Cleveland, Ohio.*

DEAN RICHARDSON HONORED

Dean R. G. D. Richardson of Brown University was the recipient of signal honors at the Annual Meeting of the American Mathematical Society held at Louisiana State University. Since 1920 Dean Richardson has been secretary of the Mathematical Society. His tact, administrative ability, and energy have been essential factors in the progress of the Society, which has tripled its size and the range of its activities in the twenty years during which Richardson has been secretary.

Jan. 1 marked his retirement from this position. To partially recognize his great services, the Society presented him with a commemorative gift and a resolution of thanks. Furthermore it was decided that the next volume of the yearly *Bulletin* published by the Society should be dedicated to him.

Dean Richardson is a man of forceful character and great personal charm. His appearance is impressive, for he has an imposing build, penetrating eyes and dominating eyebrows. He takes a keen personal interest in the welfare of the members of the Society, and he has had a major part in directing many of the recent activities of the mathematicians in this country.

Richardson was born in Canada in 1878. After studying there, at Yale University, and also in Germany, he took up a teaching career at Brown University. He was first elected Secretary of the Mathematical Society in 1920, in the period of danger and uncertainty which followed the first World War. In this position he has had a major responsibility in arranging meetings for the discussion of current mathematical research and in providing means for the publication of new discoveries in journals and books

Richardson's work in helping to develop interest in higher mathematics in this country will be greatly appreciated in the coming difficult times, when all branches of science are necessary in organizing for defense. When Richardson became Secretary in 1920, the Society had only 770 mathematicians as members. Now, thanks to his activities in increasing the membership rolls, there are over 2,310 members. The membership has tripled, and other activities have grown accordingly. In 1920 the two journals published by the Society ran together to 960 pages; today they total about 2000 pages a year. The funds for this increase have been made possible by Richardson's efficient management.

The retiring Secretary has also devoted his energy to many other important scientific activities. He labored mightily on plans for the International Congress of Mathematicians, which would have been held in this country this year had not the war intervened. These manifold services of R. G. D. Richardson were fittingly recognized by the American Mathematical Society today.

CONSERVATION "LIBRARY" ANNOUNCED

Teaching aids and suggestions to promote conservation education and practice in both rural and city communities are offered by the U. S. Office of Education. Twelve bulletins, four of them available free, form a compact library of reference facts and recommendations in this field of education. If bound into one volume, the bulletins would produce a single 700-page source-book on the subject of conservation.

Prepared by U. S. Office of Education specialists, the conservation collection includes information supplied by many governmental and educational agencies and organizations.

The general education bulletins report progress made in teaching conservation. They recommend curriculum plans and units of instruction. They suggest conservation excursions and list useful books, periodicals, and visual and auditory materials available to teachers.

Particularly addressed to teachers of elementary and secondary schools are the publications entitled, "Teaching Conservation in Elementary Schools," "Curriculum Content in Conservation for Elementary Schools," "Conservation Excursions," and "Conservation in the Education Program." To answer inquiries from many teachers, the Office has also brought out a pamphlet, "Opportunities for the Preparation of Teachers in Conservation Education."

New vocational education bulletins relate conservation to the vocational curriculum. For vocational agriculture instructors there are "Farm Forestry," "Conserving Farm Lands," and "Landscaping the Farmstead" bulletins.

The four free booklets on conservation provide "Good References" of basic materials of instruction—books, pamphlets, and periodicals, and supplementary teaching and learning aids—visual and auditory.

"Schools of the country, with their enrollments of tens of millions of learners, should become the most important ally of agencies primarily interested in conservation of our natural and human resources," said John W. Studebaker, U. S. Commissioner of Education. Inviting use of U. S. Office of Education bulletins in conservation education programs, Commissioner Studebaker urged teachers throughout the Nation to help pupils "approach adult citizenship with a much clearer realization of their responsibility and opportunity to conserve wild life, forest, land and soil, oil and minerals, and the even more important resources of health and human life."

Library

U. S. Office of Education bulletins in the conservation collection include

Conservation in the Education Program	10¢
Teaching Conservation in Elementary Schools	20¢
Curriculum Content in Conservation for Elementary Schools	15¢
Conservation Excursions	15¢
Farm Forestry	15¢
Conserving Farm Lands	30¢
Landscaping the Farmstead	15¢
Opportunities for the Preparation of Teachers in Conservation Education	5¢
Good References for Conservation Education in Secondary Schools	Free
Good References for Conservation Education in Elementary Schools	Free
Good References on Conservation of Trees and Forests for Use in Elementary Schools	Free
Good References on Conservation of Birds, Animals, and Wild Flowers for Use in Elementary Schools	Free
Total	$1.25

Free publications are available from the U. S. Office of Education, Washington, D. C. Publications for which there is a charge to cover cost of printing should be ordered from the Superintendent of Documents, United States Government Printing Office, Washington, D. C.

Let's forget everything except the welfare of our country.
—WILLIAM S. KNUDSEN

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